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Table 1

Computation of Water Mass of Some Glaciers on Severnaya Zemlya Along One or More Profiles

Название ледника 1	Галс 2	l км	p_k	M по разрезам, млн. т 3	M результ., млн. т 4
5 Академии наук	Д	43,5	1	2617186,9	2617186,9
6 Шмидта	Л М	21 23	0,477 0,523	29586,8 63907,4	57076,5
7 Альбанова	З И	16,5 19	0,465 0,535	57933,9 57675	57795,4
8 Пионер	А Б В	11,5 14,25 13,25	0,295 0,365 0,340	42675,1 57342,7 31213,8	44132
9 Ушакова	П Т	22 19	0,537 0,463	26043,9 47595,5	36022,3
10 Вавилова	—	—	—	—	520000

Note Примечание. Положение галсов и их номера см. в [5].

Key:

1. Name of glacier
2. Run
3. M along sections, millions of tons
4. Resultant M, millions of tons
5. Akademiya Nauk
6. Shmidt
7. Al'banova
8. Pioner
9. Ushakova
10. Vavilova

Note. For the position of the runs and their numbers see [5].

For precise measurement of the thicknesses of Vavilova Glacier a scheme for their measurements was developed. In constructing the scheme use was made of ground and aircraft radar runs; the surface of the glacier was broken down into squares with an area of 4 km^2 x 1.072; the coefficient 1.072 is the result of refinement of the glacier area from a map at a smaller scale than that which was used initially. The square was selected in such a way that its side was commensurable with the distance between the survey runs in the central and northern parts of the glacier; the division of the glacier into squares was accomplished from north to south and from east to west. It is assumed that the ice thickness within the limits of the square is a constant value. The numerical values are distributed in the middle of the square and reflect the mean thickness (in meters) for the entire square.

The interpolation of thicknesses from the sections was accomplished on the assumption of a smooth (graphic averagings) change in the profile of the glacier bed along the section from run to run. In such cases we took into account the change in bed relief along the last sections, along transverse sections and along near-lying sounding runs; in the eastern and southwestern sectors of the glacier the thicknesses in the squares were obtained by extrapolation. Near the radar measurements the thicknesses were assumed to be close to those for runs, taking into account the tendencies in change in thicknesses in the northern and central parts of the glacier. At a considerable distance from the run we made the following assumptions: the bed in the middle part of the glacier is even and virtually plane; the glacier surface drops off toward the edges approximately in conformity to a parabolic law; the thickness of the glacier with approach to the edge (some 3-5 km) changes in conformity to a law close to linear [this assumption is backed up by radar measurements]; the volume of a column of ice is determined as the product of the mean thickness for a square over the area of the square (in the marginal sector -- in an area of a part of the square).

The volume of Vavilova glacier was determined by computations and with the adopted assumptions was 579.8 km^3. The area of the glacier was assumed to be 1,816.8 km^2. Taking into account the mean density of ice in the glacier, which is equal to 0.9 g/cm^3, we find that the water mass of Vavilova glacier is M = 520,000,000 tons.

The table shows that the water reserve of the five mentioned glaciers is about $2.8 \cdot 10^{12}$ tons. Radar observations of the remaining glaciers in the archipelago makes it possible with a reliability greater than earlier to ascertain the total mass of water in the glaciers of Severnaya Zemlya.

The considered method can be applied to computations of the water reserves in any glaciers, including mountain glaciers. We note that for sounding of mountain glaciers it is necessary to have radar apparatus with other technical specifications in comparison with that which was used in flights over Severnaya Zemlya.

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SYNOPTIC CONDITIONS FOR CHANGES IN POSITION OF THE GULF STREAM

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 78-82

[Article by Candidate of Geographical Sciences V. P. Kapralova, Odessa Division State Oceanographic Institute, submitted for publication 1 March 1978]

Abstract: Using the coefficients of expansion in Chebyshev polynomials, a study was made of the peculiarities of variability of the pressure field over the Gulf Stream for different types of atmospheric processes in the A. I. Sorkina classification. The article defines the principal synoptic situations prevailing when there are considerable fluctuations of the Gulf Stream axis.

[Text] Despite the obviousness of the general relationships between circulation of the ocean and the atmosphere and the fact that the principal changes in velocity, direction and geographical distribution of some branches of oceanic circulation are related to atmospheric processes, in many cases it is nevertheless difficult to explain the details of spatial-temporal variability of ocean currents. This is particularly characteristic for such a current in the temperate latitudes as the Gulf Stream, which is a typical western boundary current with an easterly extension -- the North Atlantic Current.

The problem of the interrelationship between the Gulf Stream and the processes transpiring in the atmosphere has attracted the attention of many researchers, but by virtue of its complexity and the inadequacy of regular instrumental observations of the current it has not yet been studied adequately and requires further special investigations.

We carried out a comparison of the pressure fields with prolonged observations of the Gulf Stream for clarifying the relationship between the spatial and temporal variability of the position of the Gulf Stream and the peculiarities of atmospheric circulation in different seasons of the year.

As the initial material we used the mean monthly values of the position of the current axis at the meridians 80, 75, 70, 65 and 60°W during 1966-1973, obtained by Ye. I. Baranov [1], and the mean monthly pressure fields at sea level over the Northwestern Atlantic during this same period [2].

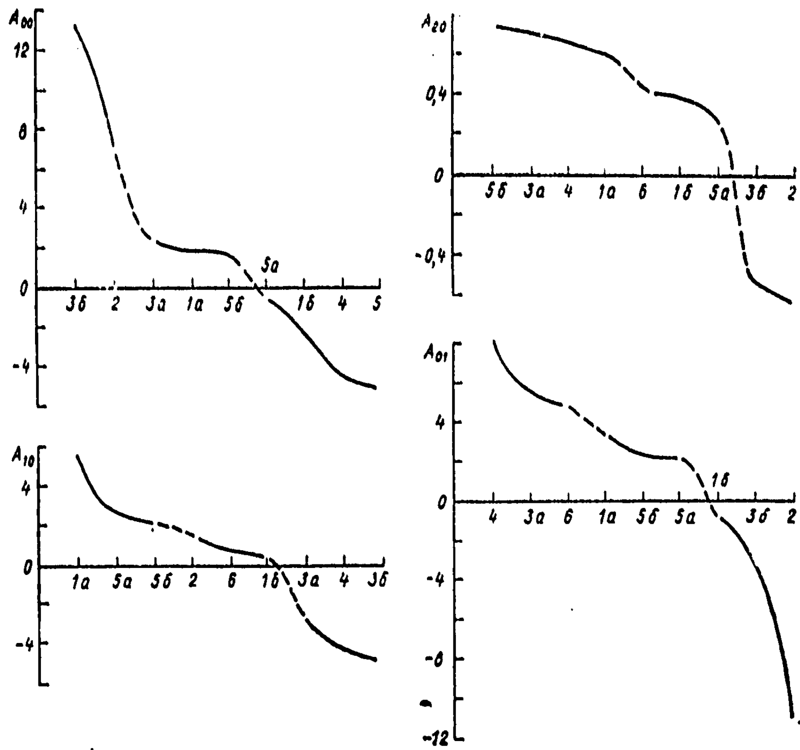

Fig. 1. Values of A_{iy} coefficients for different types of atmospheric circulation according to A. I. Sorkina classification.

All the deviations of the Gulf Stream axis from the mean monthly values during the mentioned period were divided into three groups: I -- small (0±10' in longitude), II -- intermediate (11-29' in longitude) and III -- considerable (≥30' in longitude). The breakdown found was: small -- 36%, intermediate -- about 40% and considerable deviations -- 24% of the cases.

It was established earlier [1] that the greatest deviations in the axis of the current to the north or to the south of the mean position, equal to 2.5-3° in longitude, are noted in the eastern part of the current (from Cape Hatteras to the traverse of Sable Island).

For an analysis of the intraannual changes in the position of the Gulf Stream axis we reckoned the frequency of recurrence of its deviations from the mean monthly "norm" by seasons.

Table 1 shows that in the seasonal variation the greatest frequency of recurrence of considerable deviations of the current axis at 70°W is observed in winter and summer (29% of the cases), intermediate deviations -- in winter, and small -- in summer (46% of the cases).

The greatest frequency of recurrence of Gulf Stream deviations to the north, both in the western (from Florida Strait to Cape Hatteras) and in the eastern parts of the current, is noted in the warm season of the year, that is, the Gulf Stream is displaced to the northwest, closer to the shores of the North American continent. In winter the current in its western part has a tendency to be deflected to the south, that is, the Gulf Stream deviates from the shore, being displaced to the southeast, in the direction of the open ocean.

Table 1

Frequency of Recurrence (%) of Deviations of Gulf Stream Axis from Mean Monthly "Norm" (70°W)

Сезон (1)	2 Отклонения стрежня Гольфстрима		
	малые (0±10′) (3)	средние (11—29′) (4)	значительные (> 30′) (5)
6 Зима	25	46	29
7 Весна	38	42	20
8 Лето	46	38	16
9 Осень	38	33	29

Key:
1. Season
2. Deviations of Gulf Stream axis
3. small
4. intermediate
5. considerable
6. Winter
7. Spring
8. Summer
9. Autumn

The greatest frequency of recurrence of deviations of the eastern part of the current to the south is noted during the transitional seasons: in spring and autumn (28 and 26% of the cases respectively), and in summer and winter is identical (23% of all cases each).

These conclusions are entirely satisfactorily explained on the basis of the general circulation conditions in this region.

The dependence between the peculiarities of the pressure field over the Northwestern Atlantic and atmospheric circulation over the North Atlantic sector in general was investigated using the expansion of the mean monthly pressure fields over the Gulf Stream using P. L. Chebyshev polynomials. During the mentioned period for all types of atmospheric circulation in the A. I. Sorkina classification [5] we ascertained the values of the most informative expansion coefficients A_{ij}.

It was found that for the coefficients A_{ij}, having a definite physical sense, it is possible to define the principal combinations of types of atmospheric circulation. Each of the combinations corresponds to its own level of expansion coefficients different from others (Fig. 1).

Table 2

Dependence Between Types of Atmospheric Circulation According to [5] and the A_{01}/A_{10} Parameter

Circulation types	A_{01}/A_{10}
3a, 3b	14.29-14.12
2, 5a	8.04-5.32
6, 1b, 4	3.28-1.71
5b, 1a	1.1-0.6

The greatest variations are experienced by the values of the coefficients A_{00} and A_{01}, characterizing, as is well known [4], the mean pressure field and the meridional transfer of air masses.

Subtype 3b and type 2 are characterized by the maximum value of the A_{00} coefficient.

The coefficient A_{01} attains a maximum value with meridional type 4.

The coefficient A_{10}, characterizing latitudinal transfer, assumes a maximum value for synoptic subtype 1a.

An increased level of the A_{20} coefficient is noted for subtypes 5b and 3a.

Table 2 gives what in our opinion are quite clear combinations of types (subtypes) of atmospheric circulation for one of the A_{ij} complexes: in the form of the ratio of the intensity of meridional transfer to the intensity of latitudinal circulation (A_{01}/A_{10}).

In winter with type 3 there is an increased meridionality of atmospheric processes characterized by a maximum value of the meridionality index A_{01}/A_{10}. For summer circulation subtypes (1a, 1b) there is a predominance of small A_{01}/A_{10} values.

In order to characterize the synoptic conditions for significant spatial-temporal variations of the Gulf Stream we listed the dates of considerable ($\geqslant 0.5°$ in longitude) deviations of the axis of the current from the mean monthly values ("norms") for 1966-1973 and examined the synoptic situations under which these variations were observed to the north and south. Use was made of the already mentioned classification [5] and long-term data on the intensity and migration of the Icelandic Low and the Azores High [3].

Considerable deviations of the western part of the Gulf Stream to the north (0.9°-1.2° in longitude) in winter are observed in type 3b under the influence of the southwestern part of the Canadian anticyclone or its nucleus. The Canadian anticyclone (1025 mb) is stationary over the North American continent; its ridge extends in a southeasterly direction toward the ocean to the meridian 45°W. An independent nucleus with a pressure at the center of 1025-1030 mb is formed frequently in the mentioned ridge in the region 32°N, 67-70°W.

The intensity of the Icelandic minimum, as a rule, is 4-6 mb greater than the mean long-term norm (for example, by 5.8 mb in February 1968); its center is situated to the southeast of Greenland and the trough extends to 40° N.

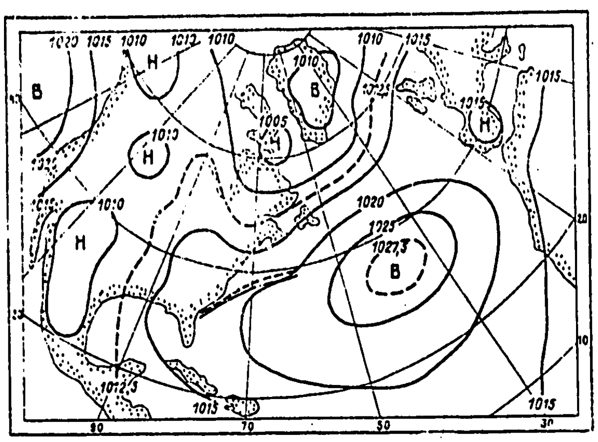

Fig. 2. Synoptic situation for considerable deviations of Gulf Stream axis to north in summer.

The Azores anticyclone is situated to the west of the Strait of Gibraltar; pressure at the center is close to the mean long-term value or less by 4-5 mb.

The eastern part of the current is deflected in winter to the north (0.6-0.8° in longitude) in the case of type 4 under the influence of the leading part of the trough or the particular cyclone (1010 mb) of the Icelandic Low. The axis of the trough extends in a southwesterly direction from Newfoundland to the Florida peninsula. The anomalies in depth of the Icelandic Low vary from 4.9 mb (in December 1968) to 13.8 mb (in February 1969). The Azores High over the western half of North America is almost destroyed; its center with a pressure of 1027.5 is situated at about 40°N, 25°W. The anomalies in the intensity of the Azores anticyclone vary from -3.3 to -9.1 mb.

Considerable (up to 1° in longitude) deviations of the Gulf Stream axis to the south in winter are noted in the case of subtype 3b and type 4 under the influence of the spur or nucleus of the Canadian anticyclone with its center (1,020 mb) over the southeastern states of the United States.

The Icelandic Low (995 mb at its center) is situated over the Norwegian Sea and its trough over Newfoundland usually forms a particular cyclone. The anomalies of intensity of the Icelandic Low in the Azores High in cases of considerable migrations of the Gulf Stream axis to the south vary in a broad range.

In winter, with a predominance of type 3 of atmospheric circulation, between the position of the Gulf Stream axis and the index of meridionality A_{01}/A_{10} there is found to be a synchronous correlation (correlation coefficient 0.45).

Considerable (0.6-1.2° in longitude) deviations of the western part of the Gulf Stream to the north in summer (Fig. 2) most frequently occur in synoptic type 1 under the influence of the westerly ridge of the Azores High, occupying almost all of the North Atlantic. The pressure at the center (35°N, 40°W) in the Azores High is greater than the mean long-term value; its intensity anomalies vary from 1.4 to 4.2 mb.

The Icelandic Low is traced in the form of particular cyclones over the northern peninsula of Labrador and Iceland; pressure at the center is within normal limits (1006-1009 mb).

In summer considerable deviations in the position of the Gulf Stream to the south (0.5-0.8°) at 70°W are noted with type 1 (subtypes a and b) under the influence of the rear part of the trough of the Icelandic Low or a particular cyclone situated to the northeast of the Labrador peninsula, with their interaction with the ridge or the nucleus of the Azores High over the southeastern states in the United States. The Icelandic Low is weakened; its intensity anomalies are -3.9 (in June 1968) and -4.4 mb (in July 1971). The Azores High (1024 mb at the center), extensive in area, occupies almost the entire North Atlantic, except for the region to the north of the 45th parallel.

Thus, the results of our investigation give an additional confirmation of the definite interrelationship between variations in the position of the Gulf Stream and atmospheric circulation during different seasons of the year.

The detected peculiarities in atmospheric processes in the case of considerable variations in position of the Gulf Stream can be used in routine work in the hydrometeorological servicing of navigation, and also in further work on prognostic recommendations for commercial fishing regions in the Northwestern Atlantic.

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THREE- AND TWO-DIMENSIONAL MODELS OF SPREADING OUT OF RIVER DISCHARGE UPON ENTRY INTO THE SEA

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[Article by Candidate of Geographical Sciences O. I. Samsonov, Moscow Affiliate of the Leningrad Institute of Water Transportation, submitted for publication 27 February 1978]

Abstract: The article gives an analysis of the possibility of three-dimensional modeling of complex cases of hypopycnal spreading out of river discharge upon entry into the sea. The author shows the applicability of two-dimensional models for describing the homopycnal discharge. A study is made of horizontal circulation in a river jet spreading out in different directions. A method for calculating the jet under these conditions is given.

[Text] When there is a considerable broadening of a channel in a place where there is a change in the bottom profile, at a place where a river enters into the sea and in other cases it is necessary to deal with river flows which are partially or completely detached from the solid bed.

A knowledge of the structure and dynamics of detached flows is necessary when investigating reformings of bar shoals, the silting of navigable channels, erosion of the lower pools at hydroelectric complexes, and in solving some ecological problems. In many problems related to detached currents it is necessary to take into account the density stratification of the waters: intrusion of a wedge of saline waters into the river mouth, propagation of a jet of impurity in a water body, designing of cooling ponds for thermal and atomic electric power stations, etc. Detached currents as a rule have a very complex structure. Frequently they are three-dimensional and nonstationary.

According to observations made at the mouth of the Mississippi [18], a river jet spreads out into the sea as an "injected" layer above the saline sea water, which in the form of a pycnocline penetrates into the river channel, sometimes for great distances from the mouth. The spreading out of the river flow is accompanied by its thinning, which leads to the generation of waves at the discontinuity between the two media. Internal waves at a distance of four-six channel widths lose their stability, are destroyed and are introduced into the river flow. This causes intensive vertical mixing. The divergence of flow at the surface in combination with the intrusion of saline waters into the river flow causes a secondary convergence at the discontinuity of the two media and somewhat below it. This gives rise to a "two-spiral" vertical circulation. A similar, but frequently more complex character of currents was also observed at the mouths of other rivers [11, 12].

Until recently in our country and abroad use has been made of simplified models of two-dimensional steady-state spreading out, making use of relatively simple equations. But a two-dimensional model is not adequate for the just-mentioned case, and as will be demonstrated below, many other cases of a current in the mouth region of a river.

The following conclusion can be drawn after analyzing the studies on river mouths carried out during recent years in our country. The set of existing models is extremely small. Models of detached currents are lacking for conditions of tides and waves; there have been no studies of cases of nonisothermic spreading out of river waters; there is no reliable model of a current in stratified flows, etc.

The prevailing situation is attributable not only to a shortage of actual observational data, but also primarily to the fact that up to the present time mathematical modeling has not been playing its proper role in investigating river mouths. In any plan for solving many problems relating to a mouth region it is necessary to combine field measurements with physical and mathematical modeling. In this connection, it seems desirable to employ the following complex approach to mouth problems:

1. Organization of preliminary expeditions for studying the boundary and initial conditions for the mathematical model (morphological investigations, measurements of the velocity field, pressure, salinity and temperature at mouth stations, and also on the boundaries of interaction between the river jet and the sea current, air flow and bottom of the water body, etc.).

2. It is economical to employ a physical model (laboratory experiment) for studying the turbulent exchange of matter, momentum, heat and other substances.

3. A mathematical model (results of numerical solution of equations) can be used in determining the most important sectors for future field investigations (zones of water circulation, zones of maximum concentration of an impurity, temperature, salinity, etc.) and for checking a system of

physical models.

Such a research approach makes maximum use of the possibilities of computations, experimentation and field measurements. If the model has been developed in accordance with the plan presented here, there will be assurance of the reliability of the predictions obtained on its basis, both the hydrological predictions, associated, for example, with a decrease in the level of the receiving basin or the removal of part of the river runoff for its diversion to arid regions, and also morphological predictions, associated with the reforming of bottom relief forms in the mouth region of a river.

As a result of accumulation of experimental and field data and broadening of the computation possibilities (use of electronic computers) it has now become possible to change over to three-dimensional models, describing jointly the effects of expulsion of the river flow by the sea, inertia, turbulent exchange and pressure. From these models, by means of neglecting factors which are not decisive under specific conditions, it is possible to obtain simpler two-dimensional models. The first step in this direction is an evaluation of the contribution of individual forces to the general motion of the river jet.

The principal forces under whose influence there will be an undetached current in the channel and which are taken into account in a two-dimensional model are the components of the inertial force

$$u\frac{\partial u}{\partial x}, \quad v\frac{\partial u}{\partial y}, \quad u\frac{\partial v}{\partial x}, \quad v\frac{\partial v}{\partial y},$$

in the horizontal plane XOY, bottom friction and the gravitational force g, offset by the vertical pressure gradient $\frac{1}{\rho}\frac{\partial P}{\partial z}$ (the latter circumstance makes it possible in two-dimensional problems to replace the

$$\frac{1}{\rho}\frac{\partial P}{\partial x} \quad \text{and} \quad \frac{1}{\rho}\frac{\partial P}{\partial y}$$

values by the longitudinal and transverse gravity components

$$g\frac{\partial H}{\partial x} \quad \text{and} \quad g\frac{\partial H}{\partial y}$$

where H is depth).

[Here and in the text which follows the u, v, w denote the components of current velocity W; all the forces are related to a unit mass; the bottom of the water body is assumed to be plane and horizontal; the origin of the rectangular Cartesian system of coordinates is at the middle of the bottom traverse at the mouth station; the XOY plane coincides with the bottom; the Z axis is directed upward.]

In detached currents the forces caused by turbulent mixing of the waters in the horizontal (with detachment from the shores) and vertical (with detachment from the bottom) directions assume decisive importance. Therefore, in an investigation of such currents it is impossible to employ the simplifying assumptions of the theory of a three-dimensional boundary layer (neglecting the component of inertial force in a vertical direction and the derivatives of shearing stresses in the coordinates x and y). In a general case it is impossible as well to neglect the inertial terms

$$w \frac{\partial u}{\partial z} \quad \text{and} \quad w \frac{\partial v}{\partial z}$$

since in a river jet spreading out in the stratified waters of a water body (which can have its own current) it is common to observe considerable vertical currents caused by the difference in the densities of the flows (in the presence of density differences gravity is not counterbalanced by the vertical pressure gradient and therefore it is impossible to replace the values

$$\frac{1}{\rho}\frac{\partial P}{\partial y} \text{ and } \frac{1}{\rho}\frac{\partial P}{\partial y} \quad \text{by } g\frac{\partial H}{\partial x} \text{ and } g\frac{\partial H}{\partial y} \text{).}$$

Now we will investigate in greater detail all the possible cases of the spreading out of a river jet in the flowing waters of a receiving water body. If the density of waters in a river and in a water body are virtually constant values (ρ_{riv} and $\rho_{body} \simeq$ const), then, adhering to Bates [14], it is possible to differentiate three types of inflow: homopycnal ($\rho_{riv} = \rho_{body}$), hypopycnal ($\rho_{riv} < \rho_{body}$), and hyperpycnal ($\rho_{riv} > \rho_{body}$), rarely encountered in nature. In the two latter cases, the jet is acted upon by an additional force. In the case of hypopycnal inflow it is directed upward and favors buoyancy of the jet, whereas in the case of hyperpycnal inflow it is directed downward, favoring its "sinking." In the presence of density stratification in a river and a receiving water body the picture is greatly complicated. Expressions of the type "the density of river waters is less than the density of waters in the water body" become uncertain and even with the introduction of some characteristic density values (such as the mean, maximum and minimum values for each flow) it is impossible to describe the behavior of a river jet in a water body in all theoretically possible cases.

For all practical purposes, however, the difference in densities at different points in the flow is usually a small value, about 0.1-2%. And although this small density difference can substantially change the structure and dynamics of the flows, nevertheless in evaluating buoyancy and "sinking" of the jet it is useful to employ the Bates classification applicable to mean $\bar{\rho}_{riv}$ and $\bar{\rho}_{body}$ values of flow densities. But here it is necessary to be very careful.

The following cases are frequently encountered in actual practice.

Direct (stable) density stratification of a fluid characterized by a density increase with depth. Direct density stratification can be caused by saline waters present in the bottom region, the presence of sediment-saturated flows, which behave as a homogeneous fluid with a density greater than the density of pure water, by a decrease in the density of the surface layers as a result of natural (solar radiation) and artificial (discharge of thermal waste waters) heating. In a stably stratified medium the river jet will be acted upon by a lift not only in the case of average hypopycnal ($\rho_{riv} < \rho_{body}$) inflow, but also in the case of homopycnal inflow ($\rho_{riv} = \rho_{body}$).

Inverse (unstable) density stratification of a fluid characterized by a decrease in density with depth. An inverse stratification of a fluid is usually observed in fresh water basins. It is usually caused by a water temperature inversion in winter. Under such conditions the lighter and warmer river jet, as a result of mixing with the cold water of the receiving water body and a decrease in temperature, sometimes to 4°C, will drop downward at some distance from the site of inflow. A "deepening" of the lighter jet of impurity was observed in Lake Baykal [4]. As noted in this study, the deepening of the jet in the case of a hypopycnal ($\rho_{riv} < \rho_{body}$), and especially in the case of homopycnal ($\rho_{riv} = \rho_{body}$) inflow, is possible when there is a temperature inversion also under marine conditions. It is only necessary that the salinity of the sea water be less than 24.7‰ (in this case the warmer and more saline bottom layers can have a lesser density the less saline and colder are the surface layers).

The deepening of the river jet in the case of hypopycnal inflow into an unstably stratified basin occurs, first of all, as a result of a temperature decrease due to the mixing of river waters with the colder waters of the basin and evaporation from the surface, and second, due to the entrainment of the jet into a vertical convection current. Convection is always observed in unstably stratified media. It is characterized by a sinking of the denser masses and the rising of lighter masses; this leads to an evening-out of densities, temperature and salinity. It therefore follows that for an investigation of jet currents in stratified waters it is necessary to make use not only of the equation of motion, but also the equations for the diffusion of salinity (or other component) and thermal conductivity.

A stable stratification of waters causes a decrease in the exchange of heat, matter and momentum primarily in a vertical direction. Unstable stratification causes intensive vertical exchange in the water layer. This leads to an asymmetric spreading out of the river jet in the stratified waters. In the first case the normal section of the jet will be elongated in a horizontal direction (the vertical dimensions are less than the horizontal dimensions), and in the second case -- in a vertical direction.

Thus, in an investigation of the problem of the spreading out of river flow upon entry into the sea in a general formulation we have no basis for neglecting any one component of the tensor of turbulent stresses or any component of the vectors of inertial forces and pressure. The only simplification which can be made here is the following. Since in all cases of practical importance for river currents and currents in water bodies the density changes little, with a conversion from the Navier-Stokes equations to the averaged equations of turbulent motion and in the derivation of the continuity, diffusion and thermal conductivity equations it is possible to neglect the density change; then we obtain the following system of equations in partial derivatives, describing three-dimensional nonsteady non-isothermic flow of an inhomogeneous incompressible fluid:

$$\nabla W = 0$$

$$\frac{\partial u}{\partial t} = -(\nabla u) W - \frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial u}{\partial y}\right) + \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial u}{\partial z}\right),$$

$$\frac{\partial v}{\partial t} = -(\nabla v) W - \frac{1}{\rho}\frac{\partial P}{\partial y} + \frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial v}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial v}{\partial y}\right) + \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial v}{\partial z}\right),$$

$$\frac{\partial w}{\partial t} = -(\nabla w) W - \frac{1}{\rho}\frac{\partial P}{\partial z} + \frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial w}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial w}{\partial y}\right) + \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial w}{\partial z}\right) - g,$$

$$\frac{\partial S}{\partial t} = -(\nabla S) W + \frac{\partial}{\partial x}\left(D_x \frac{\partial S}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial S}{\partial y}\right) + \frac{\partial}{\partial z}\left(D_z \frac{\partial S}{\partial z}\right),$$

$$\frac{\partial T}{\partial t} = -(\nabla T) W + \frac{\partial}{\partial x}\left(\alpha_x \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(\alpha_y \frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(\alpha_z \frac{\partial T}{\partial z}\right).$$

Here ε, D, α are the coefficients of turbulent viscosity, diffusion and thermal conductivity in the directions X, Y, Z, which can be determined, for example, using the formulas of Schlichting [13], Schmidt [15], Prandtl [8] and Karaushev [5].

Equations (1)-(6) contain seven unknown functions of the variables x, y, z, t:u, v, w, P, ρ, S, T. In order to close this system it must be supplemented by an equation showing the density change as a function of temperature T and salinity S.

$$\rho = f(T, S). \qquad (7)$$

For the relative values $\rho_1 = \rho / \rho_{riv}$, $T_1 = T - T_{min}/T_{max} - T$, $S_1 = S - S_{min}/S_{max} - S$ the authors of [17] used the dependence

$$\rho_1 = 1 + aS_1 + bT_1 \qquad (7')$$

where

$$a = \frac{\partial \rho_1}{\partial S_1}, \quad b = \frac{\partial \rho_1}{\partial T_1}.$$

For all cases of practical interest $a \leqslant 0.03$, $b \leqslant 0.005$.

The system of equations (1)-(7) makes it possible to solve any problem involving detached currents in rivers and water bodies. In particular, in an investigation of the isothermic spreading out of a homogeneous fluid use is made of equations (1)-(4) with four unknown functions u, v, w, P; in an examination of stationary processes the time partial derivatives of the velocity, salinity and temperature components are omitted, etc.

Sometimes in equations (2)-(4) in place of total pressure one can write the difference in total and static pressure in some homogeneous fluid with a density equal, for example, to $\bar{\rho}_{body}$. In this case in equation (4) there will be a new value

$$\frac{\bar{\rho}_{body}}{\rho} g,$$

characterizing the expulsion of the river flow by the waters of the water body. In such a form the equations (1)-(4) are called a system of equations of motion in the Boussinesq approximation.

In order to proceed to the modeling of a specific mouth by the use of equations (1)-(7) it is necessary to have a knowledge of the boundary and initial conditions. It is possible to obtain these conditions, giving a solution which in every case is unique, reflecting the specific peculiarities of a specific current, only by using preliminary expeditionary investigations which above all must yield data on the distribution of velocity, temperature and salinity at the mouth station. In a similar way it is necessary to investigate the velocity, temperature and salinity fields in the coastal current (outside the zone of action of the river jet). At the bottom it is customary to use the attachment condition (W = 0).

It is also necessary to make measurements in the surface layers of the jet. The pressure along the free surface is equal to the atmospheric pressure, and the current is directed along the tangent to the surface. Since the water surface usually has complex relief, the latter condition does not mean that at the free surface w = 0.

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The air temperature at the free surface and data on the wind regime can also be included in the boundary conditions and then we will have a model of nonisothermic spreading out under wind wave conditions. Morphological investigations are also necessary (bathymetric survey, ground samples, turbidity measurements, etc.).

The initial conditions are determined by measurement of the velocity, pressure, density, temperature and salinity "at some moment in time" for the entire space of the investigated water body.

With the spreading out of flow in a stably stratified medium the expulsion force is an obstacle to the development of exchange (especially in a vertical direction). The degree to which the flow is mixed or is stratified in density is dependent on the Froude densimetric number:

$$Fr = \frac{u}{\sqrt{\frac{\Delta\rho}{\rho_B} hg}},$$

[B = body] where $\Delta\rho = \rho_{body} - \rho_{riv}$ is the difference in densities of sea and river water, h is the thickness of the fresh water layer.

Small Fr values of the order of 1 correspond to a predominance of the repulsing force; large Fr values correspond to a predominance of inertial forces. At the mouths of large rivers the vertical density contrasts are "softened" by the exceptionally powerful inflow, completely repulsing the saline waters to the seaward of the bar crest. At the mouths of intermediate-sized and small rivers (in the absence of tides) there are conditions for appreciable density gradients at the point of entry into the sea and seaward. In such cases the values

$$\frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial w}{\partial x}\right), \quad \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial w}{\partial y}\right), \quad \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial w}{\partial z}\right),$$

characterizing turbulent mixing in a vertical direction, can be neglected in equation (4) (at least in the section to the bar crest). Such a model with a predominance of the repulsive force was investigated in [17]. Using the derived equation it was possible to describe the internal convergence, surface divergence and "two-spiral" vertical circulation of the jet not far from the place where the river enters the sea. Comparison of the results of computations with the data from expeditionary investigations at the mouth of the southern arm of the Mississippi delta was deemed to be entirely satisfactory. A three-dimensional model of steady-state nonisothermic spreading-out with a number of simplifying assumptions was examined in [16].

The flow spreading out from the river into the sea can be either detached from the bottom or nondetached. As shown by observations, with detachment of the flow from the bottom, beneath it there is formation of a so-called stagnant zone of secondary circulation currents, which are introduced into the flow from below [11].

Since the angle of free broadening out of the jet is about 12.5° and the angle of bottom slope of the river entry into the sea in the direction of the river flow current is usually a considerably lesser value, the detachment of the jet can occur only as a result of the repulsion of river waters by sea waters. (This circumstance gives, among other things, a possibility for carrying out computations of jet currents over a bottom of arbitrary configuration on the basis of theoretical studies carried out for conditions of a plane horizontal bottom). In the case of a spreading out without detachment from the bottom or with spreading out in the motionless waters of a very deep water body, when the bottom influence can be neglected, the diffusion of momentum in a transverse direction is most important. If in this case there are no well-developed convection currents (by virtue of the comments made above all these conditions correspond to homopycnal spreading out), there is no basis for expecting appreciable vertical components of the velocity of motion, averaged in time; it can therefore be assumed that w = 0. Then from equation (4) we obtain a hydrostatic law of pressure distribution. Therefore, in equations (2) and (3) the values

$$\frac{1}{\rho}\frac{\partial P}{\partial x},\ \frac{1}{\rho}\frac{\partial P}{\partial y}$$

are replaced by

$$g\,\frac{\partial H}{\partial x}\quad\text{and}\quad g\,\frac{\partial H}{\partial y}.$$

Taking this into account, equations (1)-(3) are rewritten as follows

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0, \tag{8}$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-g\frac{\partial H}{\partial x}+\frac{\partial}{\partial x}\left(\varepsilon_x\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\varepsilon_y\frac{\partial u}{\partial y}\right)+\frac{\partial}{\partial z}\left(\varepsilon_z\frac{\partial u}{\partial z}\right), \tag{9}$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-g\frac{\partial H}{\partial y}+\frac{\partial}{\partial x}\left(\varepsilon_x\frac{\partial v}{\partial x}\right)+\frac{\partial}{\partial y}\left(\varepsilon_y\frac{\partial v}{\partial y}\right)+\frac{\partial}{\partial z}\left(\varepsilon_z\frac{\partial v}{\partial z}\right). \tag{10}$$

At real mouths, when the water body does not have its own current having an appreciable transverse component, the velocity along the jet axis is much greater than the transverse components ($u \gg v$), and also the velocity changes in a longitudinal direction are much less than the changes in the transverse direction

$$\left(\frac{\partial}{\partial x}\ll\frac{\partial}{\partial y}\right).$$

This makes it possible to carry out an evaluation of the terms in equations (8)-(10). After discarding values of the second order of magnitude, from equation (10) we obtain $\partial H/\partial y = 0$, that is, we establish absence of a transverse slope of the water surface. In this case equations (8) and (9) give

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \qquad (11)$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial H}{\partial x} + \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial u}{\partial y}\right) + \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial u}{\partial z}\right). \qquad (12)$$

The simplest two-dimensional models of homopycnal spreading are based on equations (11)-(12).

I. Inertial model or model of homopycnal spreading in case of an insignificant interaction with the bottom. This model, obtained from equations (11)-(12) with

$$\frac{\partial H}{\partial x} = 0, \frac{\partial}{\partial z}\left(\varepsilon_z \frac{\partial u}{\partial z}\right) = 0,$$

was for the first time applied to river mouths by Bates [14]. Inertial spreading out of the flow is usually associated with a flow which is almost uniform in width, flowing into a deep fresh-water lake, although from time to time it is observed in newly formed mouths entering the open sea.

II. Friction model. Inflow of the purely inertial type, described by the Bates model, is a rather rare phenomenon at mouths. The prolonged deposition of sediments seaward of the lowermost mouth station, in the long run causes a substantial decrease in depths, which leads to an intensification of the role of turbulent friction against the bottom. In most cases, under natural conditions the depth of the sea where a river enters rarely exceeds the depth at the lowermost station on a river, and usually the depth at this lowermost station is greater. If under these conditions the velocity of inflow and bottom shearing stress are great (the river transports much entrained alluvium), bottom turbulent friction predominates.

It was demonstrated in [6] for the first time that bottom friction, acting jointly with the lateral diffusion of momentum, causes a substantial intensification of the spreading out of the flow and an attenuation of velocities. It was demonstrated in [9] that bottom friction favors not only an additional spreading of the entire jet, but also a broadening of the nucleus of river waters situated in the axial part of the jet (bottom friction impedes horizontal mixing). For very small water bodies the width of the nucleus of river waters is not decreased and it persists far from the shore up to the place where the jet loses its individuality and passes into the passive phase of the current. This is the profound qualitative difference between frictional spreading out and spreading out of river flow as described in the Bates inertial model, according to which the nucleus of the river waters always decreases linearly.

The frictional model, based on allowance for all terms in equations (11)-(12), except $\partial H/\partial x$, was investigated in [9]. A model using the Rayhardt-Konovalov hypotheses can be obtained from the one equation (12) by discarding the

$$v \frac{\partial u}{\partial y}$$

values in it. This model, leading after vertical averaging to the thermal conductivity equation relative to a function related by a simple expression with the longitudinal component component of plane velocity, was examined in [1, 10].

III. Channel model. In this model we dispense with the basic assumption of the theory of turbulent jets

$$\left(u \gg v, \ \frac{\partial}{\partial x} \ll \frac{\partial}{\partial y}\right),$$

but in return no allowance is made for the effect of mixing of the waters in the river and water body [7]. In other words, one uses the usual approach of two-dimensional hydraulics in an investigation of nondetached channel flows. The channel model is obtained from equation (8)-(10) by means of deleting

$$\frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial u}{\partial x}\right), \quad \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial u}{\partial y}\right), \quad \frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial v}{\partial x}\right), \quad \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial v}{\partial y}\right)$$

and subsequent vertical averaging. The model can be used under the conditions prevailing in the shallow waters at the river mouth when the nucleus of the river waters occupies the entire region of the jet currents (a case when the waters in the water body are completely washed out by the river waters). It is proposed that plans of currents be computed by the N. M. Bernadskiy method with use of a natural coordinate system. Here we can express only one consideration. Since there are considerable depth differentials in the shoals at river mouths (in a transverse direction, "furrows" and bars at the river mouths) and since there is an intensive exchange of momentum between the "furrow" and plane flows over the mouth bars, for calculating the plan of currents it is natural to use the fragments method developed by K. V. Grishanin [3], breaking the flow down into several sections and carrying out appropriate calculations for each of them.

The plane model, proposed in [9], makes it possible to compute the velocity field of a river jet spreading out in oppositely directed flows. The equation for plane motion and the continuity equation, after vertical averaging of system (11)-(12), is written as follows:

$$U\frac{\partial U}{\partial x} + V\frac{\partial U}{\partial y} = -\frac{g}{C^2 H}U^2 - g\frac{\partial H}{\partial x} + \frac{1}{\rho}\frac{\partial \tau}{\partial y} = 0, \quad \frac{\partial UH}{\partial x} + \frac{\partial VH}{\partial y} = 0.$$

Here U and V are the longitudinal and transverse components of plane velocity, C is the Chezy coefficient, τ is shearing stress.

In the case of spreading out of river flow in opposite directions in a region of mixed waters we have

$$U = U_\delta + (U_{max} - U_\delta)\, F(Y). \tag{13}$$

Here U_δ is the velocity of the forward (with $U_\delta > 0$) or return (with $U_\delta < 0$) flows,

$$F(Y) = 1 - 6\,Y^2 + 8\,Y^3 - 3\,Y^4,\quad Y = \frac{y - \delta_n}{\delta_c},$$

[n = n(ucleus); c = m(ixed)] where δ_n is the half-width of the nucleus of river waters, δ_c is the zone of mixed waters.

By virtue of the symmetry of the examined currents relative to the X-axis we can investigate only the region of mixing corresponding to positive y and Y ($\delta_n \leqslant y \leqslant \delta_n + \delta_m$, $0 \leqslant Y \leqslant 1$). In this case the function F(Y) decreases from 1 to 0.

Equation (13) shows that with spreading out in the return flow ($U_\delta < 0$) along the lateral boundaries of the jet there can be regions of return flow even when a current in the direction of the sea persists in the axial part of the jet.

The change in current velocity in the zone of river waters is

$$U^2_{max}(x) = [U_0^2 + 2\,g\,(H_{10} - H_1)]\,e^{-2fx}, \tag{14}$$

where
$$\frac{\partial H}{\partial x} = \frac{\partial H_1}{\partial x}\,e^{-2fx},$$

U_0 and H_{10} are the values of jet velocity and the function H_1 at the lowermost station at the river mouth, $f = g/C^2H$. Equation (14) shows that the maximum velocity in the jet decreases if H_1 is an increasing function, that is, in the backwater sector ($\partial H/\partial x > 0$).

The condition of absence of an increasing current in the axial part of the jet, according to equation (14), is written as follows: $\frac{U^2}{2g} > H_1 - H_{10}$.

It is interesting that in the case of a direct flow, as follows from (14), when the current ceases in the axial part, the current retains its initial direction at the sides of the jet. As noted above, in cases of counterflow the return current forms first in the marginal parts of the jet. Thus, each of these cases corresponds to a circulation of the opposite direction. The circulations investigated here theoretically were observed by the author on the bars in Tazovskaya Guba (bay). Computations by the proposed method were made separately for river zone waters using formula (14) and for a zone of mixed waters using formula (13).

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FREEZING OF LOWLAND SWAMPS AND THE INFLUENCE OF THEIR DRAINAGE ON THE DEPTH OF FREEZING

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[Article by I. M. Romanova, Tyumen' Hydrometeorological Observatory, submitted for publication 1 February 1978]

Abstract: In this article, for the first time for the conditions prevailing in the southern part of Tyumenskaya Oblast, the author gives an analysis and generalization of materials on the freezing of a peat deposit in undrained lowland swamps. It was possible to obtain the principal quantitative characteristics determining the freezing process: thickness of the frozen layer, intensity of increase in seasonal permafrost and thermal index of swamp freezing. The article gives a comparison of the results with the investigations of other authors. On the basis of an analysis of data from parallel observations it is shown that there is a change in the depth of freezing under the influence of drainage and a formula is derived for computing the thickness of the freezing layer in the drained peat deposit.

[Text] During recent years the Party and government have been devoting great attention to the problem of the exploitation of swamps and swampy lands in the nonchernozem zone of the RSFSR. Western Siberia is the swampiest region in the Soviet Union. Ninety-six percent of the territory of Tyumenskaya Oblast, located in the West Siberian Plain, is occupied by forests, lakes and swamps. In implementing the resolutions of the Party and government, in Tyumenskaya Oblast specialists are carrying out a great volume of melioration work. In the Tenth Five-Year Plan alone, plans call for the drainage of 30,000 hectares of land. In addition, considerable areas of swamps, drained at the present time for the production of peat, will be put into the hands of kolkhoz and sovkhoz enterprises in the oblast. When using meliorated lands for agricultural crops it is necessary to have data on the freezing and thawing of swamps.

The freezing of soil and ground of different mechanical composition has been investigated for more than 70 years. However, the study of freezing of undrained and swampy territories began relatively recently. The investigations of A. D. Dubakh [5], A. F. Pechkurov and M. A. Kaplan [9], A. P. Domanitskiy [4] and A. D. Kibal'chich [7] and others have established a number of peculiarities in the freezing of swamps. The authors have emphasized examination of the hydraulic-thermal properties of the frozen layer of swamps. Since 1953 S. A. Chechkin [18] has carried out physical-statistical investigations of the freezing of swamps for the purpose of obtaining the quantitative characteristics determining the process of freezing of the peat deposit. As such characteristics S. A. Chechkin proposes use of thickness of the frozen layer h(cm), intensity of increase in seasonal permafrost i (cm/day), and the thermal index of freezing of swamps η(°C/cm).

At the present time the quantitative long-term characteristics of the freezing of swamps, obtained using data from direct measurements of the network of swamp stations, are very limited. Some indirect evaluations of the freezing of uninvestigated swamps were carried out using relatively limited initial material. At the same time, the quantitative characteristics of the parameters h, i and η for undrained swamps are of scientific and practical interest.

In this connection, in the example of the Tarmanskiy swamp area, we investigated the considered characteristics of freezing of swamps. The total number of processed and analyzed data is more than 1,500. The observation points take in the most characteristic microlandscapes for the investigated data and all types of microrelief; this makes it possible to draw conclusions concerning the possibility of using the data obtained below in characterizing the freezing of similar swamp microlandscapes. A brief description of the microlandscapes and the peat deposits in the investigated swamp is given in [14, 15].

Observations of the freezing of an undrained peat deposit in the Tarmanskiy swamp area have been carried out since 1960 in five microlandscapes: hummocky sedge, sedge-hypnospore, hypnospore-sedge-mosaic and swampy-wooded. The observations characterize low-lying and high-lying sectors of microrelief and are carried out once each five days, and during thawing of the swamp -- each day. The measurements of the depth of freezing are made using a Danilin permafrost meter and using monoliths.

In the drained sector of the swamp, used for peat production by the cutting method, observations of freezing are also made once each five days in the middle of the map and once each ten days along a route extending 2 km each 20 m. Snow surveys are made along this same route. Observations are made daily during thawing.

The increase in the frozen layer in undrained swamps during the cold season occurs with different intensities (i cm/day). The greatest rate of formation of the frozen layer was noted during the initial autumn-winter period. With respect to the conditions for growth of the frozen layer it is easy to trace two periods of freezing which differ substantially from one another with respect to a whole series of quantitative indices. This peculiarity of the freezing process, most characteristic for physiographic regions with a stable snow cover, has been noted in the studies of V. V. Romanov [11], S. A. Chechkin [18], and others. The first period, characterized by intensive freezing, begins from the time of a stable transition of air temperature through 0°C to negative values. The end of this period coincides with the formation of a stable snow cover of a definite depth. According to the data published by A. G. Gayel' [3] and P. I. Koloskov [8], for mineral soil and ground the critical depth of the snow is 15-18 cm. Applicable to undrained swamp deposits, according to the investigations of S. A. Chechkin [18] and O. A. Belotserkovskaya [1], this value varies in the range 5-10 cm. For the conditions of the Tarmanskiy swamp area the critical depth of the snow is 6-8 cm. For mineral soils in this zone it is 12 cm. The difference in the critical depths of the snow in swamp areas and mineral soil is attributable to the dissimilar moistening of the upper layers.

Table 1

Mean Long-Term Intensity of Growth of Frozen Layer (i cm/day)

Микроландшафт 1	2 Осень		3 Зима	
	повышение 4	понижение 5	повышение 4	понижение 5
6 Грядово-мочажинный	0,80	0,69	0,26	0,30
7 Осоково-гипновый	1,40	1,10	0,30	0,30
8 Осоковый кочкарник	0,90	1,00	0,20	0,20
9 Гипново-осоково-мозаичный	—	0,70	—	0,25

Key:
1. Microlandscape
2. Autumn
3. Winter
4. increase
5. decrease
6. Ridged-moss
7. Sedge-hypnospore
8. Hummocky sedge
9. Hypnospore-sedge-mosaic

The second period of freezing continues until a maximum depth of freezing is established. According to the investigations of S. A. Chechkin [18], in swamp deposits this period ends 4-8 days earlier than the onset of snow cover destruction. Our data coincide with the results of an analysis by S. A. Chechkin.

Above we mentioned the difference in the quantitative characteristics of the freezing process during the first and second periods. This was caused both by the nonidentical heat-insulating role of the snow cover of different depth and by the conditions of vertical dissemination of heat in the swamp deposit.

In order to evaluate the intensity of increase in the frozen layer we carried out computations of i separately for the autumn and winter periods for the entire series of observations. The results of the computations are presented in generalized form in Table 1. An analysis of the data in the table shows that a change in the intensity of freezing even in the limits of one swamp microlandscape during the autumn period is dissimilar. During this time the greatest rate of freezing was noted in the sedge-hypnospore microlandscape. The freezing process transpires identically in ridged-mossy and hypnospore-sedge-mosaic microlandscapes; this is associated with the uniformity of conditions for these microlandscapes, exerting an influence on the freezing of the peat deposit. In winter the difference in the intensity of freezing, both for different types of microrelief, as well as for different types of microlandscapes, is considerably less; for all intents and purposes the intensity during this period for the entire mass is identical (0.2-0.3), which is attributable to the influence of the snow cover.

A considerable role in increase in the thickness of the frozen layer is played by the snow cover, which is a good natural heat insulator, safeguarding the peat deposit against cooling and thereby protecting it against deep freezing. In the Tarmanskiy complex the snow-free peat deposit freezes to a depth of 1.5-2 times greater than under the snow cover. According to the investigations of S. A. Chechkin [18], applicable to the undrained swamps of the European USSR, these relationships on the average are equal to 3.5-6.0. In mineral soils and ground, according to the data of a number of authors [8, 19], the similar relationship is 2.5-4.0.

In order to clarify the role of the snow cover in the freezing of the principal types of swamp microlandscapes, we will examine the values of the heat index of swamp freezing η (°C/cm), which is the sum of the negative mean daily air temperatures necessary for forming a frozen layer with a thickness of 1 cm [18]. The η value takes into account many factors in the state of the active layer at the time of freezing and varies in dependence on the hydrometeorological peculiarities of the year, the thickness of the frozen layer and the physical properties of the active layer. Computations of the η values were made for the autumn and winter periods of freezing. The η value was determined on each day of measurements of thickness of the frozen layer during the entire period of observations separately for "up" and "down" microrelief elements. In generalized form the results of the computations are given in Table 2. The table shows that the η value is dependent on the depth of the snow cover. The greater the depth of the snow cover, the greater is the η value. The influence of the snow is confirmed by the η values for elevated and depressed microrelief types. For elevations the thermal index as a rule is 1.5-2.5 times less than in depressions. The computed data for the Tarmanskiy complex agree well with the investigations of P. I. Serebryanskaya [17], carried out for Central Baraba, and A. G. Gayel' [3] for the meadow soils of the northern Aral region. According to data published by P. I. Serebryanskaya, the thermal index for lowland swamps during the winter period is 42°C/cm, for headwater swamps -- about 39°/cm, according to A. G. Gayel' -- about 37°/cm. For the Tarmanskiy swamp area η in elevated sectors varies during this same period from 34 to 36.8°C/cm, in depressions -- from 38 to 51°C/cm.

Table 2

Mean Long-Term Value of Thermal Index of Freezing of Swamps (η° -- C/cm)

	Микроландшафт 1	2 Осень		3 Зима	
		повышение 4	понижение 5	повышение 4	понижение 5
6	Грядово-мочажинный	3,0	6,8	36,8	44,1
7	Осоково-гипновый	2,2	5,4	34,5	38,2
8	Осоковый кочкарник	2,6	6,2	34,0	51,0
9	Гипново-осоково-мозаичный	—	6,8	—	44,8

Key:

1. Microlandscape
2. Autumn
3. Winter
4. elevation
5. depression
6. Ridged-mossy
7. Sedge-hypnospore
8. Hummocky sedge
9. Hypnospore-sedge-mosaic

Table 3

Mean Long-Term Values of Coefficient

	Микроландшафт 1	Осень 2	Зима 3	Весна 4
5	Осоковый кочкарник	2,92	1,68	1,36
6	Осоково-гипновый	2,78	1,64	1,33
7	Грядово-мочажинный	1,17	1,08	1,11

Key:

1. Microlandscape
2. Autumn
3. Winter
4. Spring
5. Hummocky sedge
6. Sedge-hypnospore
7. Ridged-mossy

An analysis of materials on freezing shows that in individual years the influence of the snow cover on the increase in thickness of the frozen layer is considerably greater than the increase in the sums of negative air temperatures. For example, the sum of the negative mean daily air temperatures by 20 December 1967 attained 257°C, and by 20 December 1970 -- 586°C; the thickness of the frozen layer, however, was 52 and 40 cm respectively, that is, despite the comparatively severe winter, the freezing of the peat deposit in 1970 was 12 cm less. This phenomenon is attributable, in particular, to the difference in the depth of the snow cover. In 1967 the snow depth on 20 December was only 11 cm, and in 1970 -- 40 cm. A similar result is obtained from a comparison of observational data for winter in 1961 and 1963. The sum of the mean daily negative temperatures by 10 January in these years is identical (924 and 927°C), but the difference in the thicknesses of the freezing layer was 18 cm (53 and 71 cm). The snow depth in 1961 was 50 cm, in 1963 -- 38 cm. Thus, the snow cover plays one of the principal roles in formation of the frozen layer in swamps.

Table 4

Comparison of Mean Monthly Snow Depths in Drained (D) and Undrained (U) Sectors of Swamp Complex

Период 1	2 Ноябрь		3 Декабрь		4 Январь		5 Февраль		6 Март	
	О 7	Н 8	О	Н	О	Н	О	Н	О	Н
1972--1973	—	—	14	23	18	27	28	38	19	42
1973--1974	2	4	12	18	16	25	21	35	27	33
1974--1975	3	12	3	25	16	33	21	39	17	40

Key:
1. Period
2. November
3. December
4. January
5. February
6. March
7. Drained (D)
8. Undrained (U)

In addition to the snow cover, a considerable influence is exerted on the freezing of undrained swamps by vegetation [12, 13], moisture content and microrelief of the surface in the active layer of swamps. Vegetation favors snow accumulation on the swamp surface, retention of the snow cover in a more unconsolidated state and thereby safeguards the upper horizons of the swamp deposit from strong freezing. The joint influence of the moisture content of the peat deposit and the microrelief of the swamp microlandscapes on the degree of freezing is expressed by the value of the coefficient $\varphi = h_{pos}/h_{neg}$, where h_{pos} is the depth of freezing of positive forms of microrelief, h_{neg} -- negative forms of microrelief. We computed the φ values for each day of measurements of the thickness of freezing for all microlandscapes using data from long-term observations. In generalized form the φ values are given in Table 3. Analysis of the φ coefficients shows that it is always greater than 1, that is the value for elevated microrelief forms is always greater than for depressions. The φ value also does not remain constant during different periods of freezing. The coefficient attains its maximum value in the autumn snow-free period, and this indicates that the joint influence of moisture content and forms of microrelief is greater than in autumn. The analytical data agree with the results of investigations made by S. A. Chechkin [18].

The characteristics of a number of parameters determining the process of freezing of swamps is related to undrained swamps of the lowland type.

For investigating the influence of drainage on the thickness of the freezing layer we carried out a comparison of the results of parallel observations of the depth of freezing of drained areas in peat production and undrained peat deposits during 1972-1975. The analysis indicated that the depth of freezing in the drained sector is distributed extremely nonuniformly over the area. This is attributable to the peculiarities of deposition of the snow cover in drained swamps. During winter in the drained sector there is a deflation of the snow, the snow is accumulated in depressions, in canals, and the elevated sectors remain bare. The depth of the snow in the sector in individual places varies from 0 to 40 cm; the corresponding thickness of the frozen layer varies from 46 to 80 cm. The freezing of the drained deposit by 20-40 cm exceeds the freezing of the undrained deposit, which in turn was caused by a considerably lesser depth of the snow in the drained swamp in comparison with an undrained swamp (Table 4). The increase in freezing of drained swamps in the territory in the southern part of Tyumenskaya Oblast is mentioned in the investigations of E. D. Vvedenskaya and I. F. Rusinov [2].

The nonuniformity of deposition and small depth of the snow cover during the course of the entire winter favors a great intensity of freezing of the drained deposit in winter. Prior to appearance of snow with a depth of 20 cm the intensity of freezing is 1.2 cm/day. According to data from three years of observations, such a snow depth was noted during the last few days in January. During February, March, after the snow had reached a critical depth, the intensity of increase in thickness of the frozen layer was equal to 0.4 cm/day. Thus, an analysis of observational data indicates an increase in the intensity of freezing of the drained deposit in winter in comparison with the undrained deposit.

In characterizing the freezing of the undrained peat deposit it was pointed out that the principal factors exerting an influence on the increase in the depth of freezing are an increase in the sum of negative temperatures, depth and density of the snow, vegetation, and form of microrelief. A swamp drained and in peat production has an open, level surface free of any vegetation. The levels of the swamp waters in the drained area are usually 1.5-2.0 m below the surface. Thus, the influence of moistening, vegetation, and forms of microrelief on the freezing of the drained deposit in any specific case can be neglected. Taking into account that the snow depth in a drained swamp is considerably less, as is confirmed by data from direct observations, cited in Table 4, it can be postulated that the main role in increase in the thickness of the freezing layer in drained swamps is played by air temperature. Proceeding from this point of view, on the basis of materials from three years of observations we constructed a graph of the dependence of the depth of freezing of the drained deposit on the square root of the sum of the mean daily negative air temperatures (Fig. 1). The correlation coefficient was 0.95. The dependence has a linear form

$$h = 1{,}8\sqrt{\Sigma(-t\,^\circ C)} - 3, \quad (1)$$

where h is freezing depth.

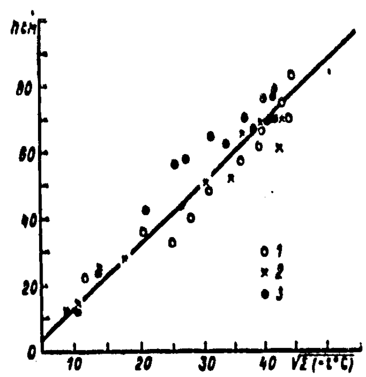

Fig. 1. Dependence of depth of freezing of drained peat deposit on sum of mean daily negative air temperatures. 1) 1973; 2) 1974; 3) 1975

Table 5

Computation of Freezing Depth of Undrained Peat Deposit Using Formula (1)

Дата, на которую произведен расчет 1	$\sqrt{\Sigma(-t^\circ C)}$	Глубина промерзания, см 2		Относительная ошибка, % 5
		рассчитанная 3	фактическая 4	
6 10 ноября	9,2	13	14	7,2
20	10,3	16	16	0
30	13,9	22	26	15,4
7 21 декабря	21,0	35	36	2,8
31	24,7	41	34	20,6
8 10 января	28,1	48	40	20,0
20	30,4	52	51	2,0
31	31,4	59	63	6,3
9 10 февраля	38,6	67	62	8,1
20	39,7	68	68	0
28	40,0	69	74	6,8
10 10 марта	43,1	74	73	1,4
20	43,0	74	67	10,4
31	41,3	71	75	5,3

Key:
1. Date for which computations made
2. Freezing depth, cm
3. Computed
4. Actual
5. Relative error
6. November
7. December
8. January
9. February
10. March

Using the derived equation, for different periods in winter we carried out computations of the depth of freezing of a drained deposit and computed the error in computations from the actual values. The greatest error is 20.6%. The results of the computations are presented in Table 5. It must be remembered that the formula was derived on the basis of a short series of observations and requires further checking, but even now it can be recommended for computing the depth of freezing of lowland swamps, drained for the purposes of peat production, situated under physiographic conditions similar to the Tarmanskiy swamp complex.

Summary

1. This investigation of the process of freezing of an undrained deposit under the conditions prevailing in the southern part of Tyumenskaya Oblast made it possible to refine a series of computed characteristics of freezing for lowland types of swamp microlandscapes.
a) The snow depth for the conditions prevailing in the Tarmanskiy swamp complex, with which the winter period of freezing of the peat deposit begins, is 6-8 cm.
b) The intensity of freezing is considerably greater during autumn and varies even within the limits of a single microlandscape. In winter, as a result of leveling-out of the thermal resistance of the snow cover, the intensity of freezing is virtually identical over the entire area.
c) The depth of freezing for positive forms of microrelief in swamps h_{pos} considerably exceeds the depth of freezing of negative forms h_{neg}; the h_{pos}/h_{neg} ratio attains its maximum values during the autumn snowfree period.

2. The depth of freezing of a drained area in peat production exceeds by 20-40 cm the depth of freezing of an undrained area.

3. The intensity of increase in the frozen layer in drained swamps during winter is considerably greater than in undrained swamps.

4. Under conditions of insignificant snow cover depths, for computing the freezing depth of a drained deposit it is possible to use only the air temperature values. The greatest relative error in the computations in this case is 21%.

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REASONS FOR UNDERSIZED GRAIN FORMATION AND MEASURES FOR PREVENTING IT

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 101-106

[Article by Candidate of Geographical Sciences I. V. Svisyuk, Weather Bureau, Rostov-on-Don, submitted for publication 20 April 1978]

Abstract: The article gives an analysis of the reasons for undersized grain formation in grain crops in 1977 in the Northern Caucasus, in the Lower Volga Region and in Rostovskaya Oblast. An attempt is made to predict this phenomenon and introduce corrections to the forecast of the crop yield of winter wheat and spring barley. Recommendations are made on the alleviation of the harmfulness of undersized grain formation.

[Text] In investigating the reasons for the formation of undersized grain in the Northern Caucasus, Lower Volga region and in Rostovskaya Oblast, we became convinced that they are not the same, being dependent for the most part on weather conditions developing during the spring-summer period, and to some degree on the agricultural techniques employed.

The principal reason for the formation of undersized grain in these regions is drought, due to which, on the average, in two to four years out of ten in different regions in the mentioned territory grain is formed which is not fully developed. The second reason is excessive overmoistening during the period of grain formation, resulting in undersized grain formation. Over great areas this reason prevails extremely rarely. During the last 40 years it was observed only twice: in 1933 and in 1977.

In 1977, in the eastern regions of Volgogradskaya Oblast and in some southeastern rayons of Stavropol'skiy Kray (Fig. 1) the undersized grain was caused by drought. The sown crops in the trans-Volga region of Volgogradskaya Oblast were subjected to particularly severe drought. There during the period of grain formation the moisture reserves in the meter soil layer were less than 10 mm, less than 30 mm of precipitation fell during the period, and in many regions -- less than 20 mm. The mass of 1,000 grains was not more than 30 grams.

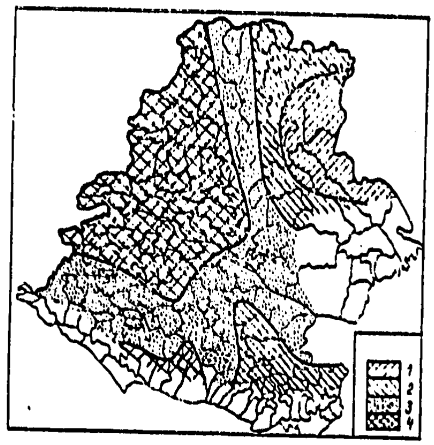

Fig. 1. Mass of 1,000 grains of winter wheat in harvest of 1977. 1) 21-29 g (drought), 2) 30-39 g (drought), 3) 40-49 g, 4) 30-39 g (undersized grain formation)

In the eastern regions on the right bank of the Volga there was also (although lesser) undersized grain formation -- the mass of 1,000 grains was 31-38 g. Here the supplies of productive moisture during the period of grain formation in the meter soil layer were 40-70 mm, but during this period there was from 20 to 50 mm of precipitation. In addition, at the end of the phase of milky ripeness there was a marked increase in daytime temperatures (from 20-22 to 28-31°C). This caused an acceleration of the end of grain formation, and in the long run, incomplete filling of the grain.

Similar conditions also developed in the eastern and northeastern regions of Stavropol'skiy Kray, with the single difference that there the period of formation and filling of grain occurred approximately a week earlier than in Volgogradskaya Oblast and therefore the marked temperature increase at the end of the third ten-day period in June was virtually not reflected in the yield formation. In these regions filled grain was formed (the mass of 1,000 grains exceeded 40 g), whereas in Ipatovskiy Rayon, where the supplies of productive moisture in the meter soil layer during the period of forming and filling of grain were held in the range 40-60 mm and about 50 mm of precipitation fell, a good yield was obtained for the conditions prevailing in this region.

The conditions were somewhat poorer in the Blagodarnenskiy, Prikumskiy, Stepnovskiy and Kurskiy Rayons in Stavropol'skaya Oblast, where during the period of formation and filling of grain the moisture reserves were inadequate (in the meter layer -- 15-20 mm) and also little precipitation fell -- 20-30 mm. This also caused undersized grain in winter wheat. The mass of 1,000 grains in the enumerated regions was 34-39 g, that is, the same as in the eastern right-bank regions of Volgogradskaya Oblast.

Favorable conditions for the forming and filling of grain were created in a narrow zone in the western regions of Volgogradskaya Oblast, in most of the rayons of Stavropol'skiy and Krasnodarskiy Krays, where during the period of forming and filling of grain the moisture reserves in the meter layer remained for the most part in the range 40-70 mm and from 50 to 90 mm of precipitation fell. In these regions the mass of 1,000 grains was 40-43 g, locally even greater than 50 g.

Table 1

Decrease in Grain Unit After Entry of Plants into Total Maturity Phase in Dependence on the Quantity of Falling Precipitation During Harvesting Period According to Observations in Three Rayons of Rostovskaya Oblast in the Summer of 1977

Район 1	Культура 2	Сумма осадков за период, мм 3		Уменьшение натуры зерна по периодам, г 4	
		5—31/VII	1—15/VIII	5—31/VII	1—15/VIII
5 Матвеево-Курганский	Озимая пшеница 8	194	83	15	10
	Яровой ячмень 9	—	—	—	11
6 Зерноградский	Озимая пшеница .	114	63	11	9
	Яровой ячмень .	—	—	—	20
7 Зимовниковский	Озимая пшеница 8	64	2	2	7
	Яровой ячмень 9	—	—	—	7

Key:
1. Rayon
2. Crop
3. Precipitation sum during period, mm
4. Decrease in grain unit by periods, g
5. Matveyevo-Kurganskiy
6. Zernogradskiy
7. Zimovnikovskiy
8. Winter wheat
9. Spring barley

In the extreme western regions of Volgogradskaya Oblast, in the entire territory of Rostovskaya Oblast and in the northern rayons of Krasnodarskiy Kray, where during the period of forming and filling of grain there was from 90 to 150 mm of precipitation, and locally up to 200 m, there was also undersized grain formation, but there it was caused by a phenomenon which is very rare for these regions -- an inadequate development of grain size. It was established in the investigations of S. I. Kharizomenov [3] that undersized grain formation is most probable when there is abundant precipitation both before and after the onset of grain formation. M. I. Knyagichev and A. I. Nosatovskiy [1, 2], citing investigations of a number of scientists, indicate that the undersized formation of grain in the case of very moist and warm weather during the period of filling and maturing transpires as a result of a great expenditure of dry matter in respiration and direct washing out of nutrients by rains. The experiments of N. G. Kholodnyy which they have cited show that under the influence of artificial sprinkling the weight of the grain can be reduced by 16.5-48%, depending on the maturity phase of the grain during which the ear was exposed to the sprinkling. The fact that under the influence of rain there is an exosmosis of sugar, a hydrolytic breakdown of starch and an outflow of plastic substances was demonstrated by the presence of sugar in the water flowing from the ears. The undersized formation of grain can also occur after harvesting, as long as the grain moisture content is greater than 25% [2], that is, also in sheaves after mowing of the grains. This is also indicated by the data published by K. Ye. Murashkinskiy, who notes that in such cases "sweet dew" appears on the ears, this being an indicator of the washing out of mobile carbohydrates.

M. I. Knyagichev [1] mentions the possible disturbance of metabolism under the influence of direct washing-out of sugars. This also leads to an increase in puniness of the grain.

Our investigations, carried out over great areas in summer in 1977, show that the undersized formation of grain frequently is accompanied by other damage to plants, especially the falling down of grains, increasing the moisture content of the grass stand and worsening metabolic conditions in the plant.

In addition, there is a washing out of mobile forms of nitrogen from the soil by abundant rains before and after the onset of filling of the grain, especially in unfertilized fields of nonfallow precursors. In 1977 in the upper soil layers during the period of formation and filling of grain there were only traces of such nitrogen.

Table 2

Decrease in Crop Yield of Winter Wheat in Dependence on Delays in its Harvesting and Quantity of Precipitation During June in Some Regions of Rostovskaya Oblast in 1977

Район 1	Сумма осадков за июнь, мм 2	Задержка уборки после наступления фазы полной спелости, дни 3	Снижение урожайности, % 4
5 Октябрьский	134	10	45
6 Чертковский	140	8	39
7 Каменский	130	8	26
8 Верхнедонской	118	5	20
9 Азовский	128	5	10
10 Морозовский	85	1	0
11 Ремонтненский	122	3	0

Key:
1. Region
2. Sum of precipitation for June, mm
3. Delay in harvest after onset of total maturity phase, days
4. Reduction in crop yield, %
5. Oktyabr'skiy
6. Chertkovskiy
7. Kamenskiy
8. Verkhnedonskiy
9. Azovskiy
10. Morozovskiy
11. Remontnenskiy

The undersized grain formation was accompanied as well by the "invasion" phenomenon due to damage of the plants by rust and other fungal diseases. Blight locally caused a premature dying off of the leaves and cessation of assimilation processes in plants even before they entered into the phase of golden ripeness, which also led to the formation of undersized grain.

A decrease in grain mass also transpired after onset of total maturity of the grains; this is traced easily in Table 1, cited below.

It should be noted that under identical conditions the decrease in the mass of grain during this period was observed more in those places where the grains after their entry into total maturity remained unmowed for a longer time. However, in fields where the grains were mowed not later than 3-4 days after their entry into the phase of total maturity the decrease in yield was insignificant. With an increase in time between the onset of total maturity and mowing the decrease in crop yield also increased (Table 2).

A delay in the harvest due to heavy rains led to a strong overgrowing of low-growing grains (especially spring barley) by weedy vegetation, which also increased the yield losses.

In clarifying the nature of the undersized grain formation, we attempted to find the correlation between the mass of 1,000 grains as an index characterizing the completeness of filling of the grain and meteorological conditions. We used the correlation of the mass of 1,000 grains and air temperature and precipitation for different periods during the spring-summer growing season. Since the summer of 1977 the different regions of the territory were exceptionally diversified with respect to weather conditions; this made it possible to carry out investigations in a wide range and clarify simultaneously the influence of both drought and overmoistening on the forming and filling of winter wheat grain.

The closest correlation between the mass of 1,000 grains (y) was found with the precipitation sum during the period from flowering to golden ripeness (x). An influence was also exerted by the techniques and equipment used in cultivation. Six equations were derived for winter wheat and two equations were derived for spring barley.

For winter wheat for optimum sowing times on bare fallow in sovkhoz and kolkhoz fields

$$y=-0{,}0024\,x^2+0{,}36\,x+31{,}2. \quad (1)$$

For winter wheat of the Severodonskaya variety in the state strain testing station under these same conditions

$$y=-0{,}00038\,x^2-0{,}067\,x+32{,}06. \quad (2)$$

For winter wheat, sown at optimum times in the case of nonfallow fertilized precursors,

$$y=-0{,}0023\,x^2+0{,}325\,x+32{,}06. \quad (3)$$

For winter wheat sown at late times in the case of nonfallow fertilized precursors,

$$y=-0{,}0033\,x^2+0{,}520\,x+22{,}57. \quad (4)$$

For winter wheat sown at optimum times in the case of nonfallow precursors without fertilizers,

$$y=0{,}00003\,x^3-0{,}0095\,x^2+0{,}83\,x+19{,}3. \quad (5)$$

For winter wheat, sown at late times in the case of nonfallow unfertilized precursors,

$$y=0{,}000004\,x^3-0{,}0051\,x^2+0{,}65\,x+180. \quad (6)$$

For spring barley with optimum sowing times in kolkhoz and sovkhoz fields

$$y=-0{,}070\,x+51{,}0. \quad (7)$$

For spring barley with optimum sowing times in fields at state strain testing stations

$$y=-0{,}067\,x+56{,}0. \quad (8)$$

The correlation ratios and correlation coefficients for the cited equations fall in the range 0.72-0.96. The errors in the equations are $S_y = \pm 4-9$ g. A graphic representation of equations (1)-(8) is shown in Fig. 2.

The derived equations show that an increase in precipitation to 70 mm (60-80 mm) during the period of formation and filling of grain improves the conditions for the transpiring of these highly important processes, as a result of which the mass of 1,000 grains is increased. With 70 mm of precipitation it is highest, and thereafter with an increase in precipitation during this same period there is a decrease.

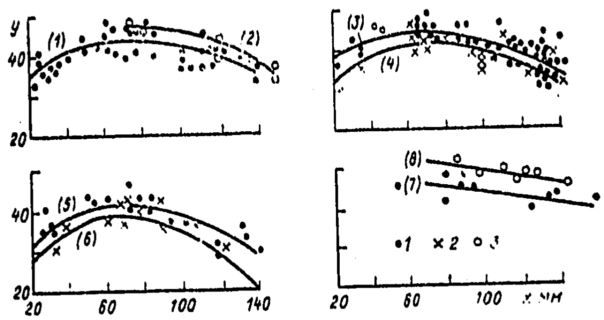

Fig. 2. Dependence between mass of 1,000 grains (y) and the quantity of precipitation (x) falling during period of formation and filling of winter wheat and spring barley grain. 1) optimum sowing times, 2) late sowing times, 3) optimum sowing times in fields of state strain testing stations.

Table 3

Correction for Undersized Grain Formation for Different Quantities of Precipitation Falling During Periods of Formation and Filling of Grain

Сумма осадков, мм 1	Снижение урожайности, % 2	Сумма осадков, мм 1	Снижение урожайности, % 2
80	0	120	16
90	4	130	20
100	6	140	27
110	11	150	35

Key:
1. Precipitation total, mm
2. Decrease in crop yield, %

A mass of 1,000 grains is formed which is higher in the case of fallow precursors, optimum sowing times, in fertilized fields and in fields of state strain testing stations. The course of formation and change in the mass of 1,000 grains is similar to the course with any agricultural techniques used in cultivation. But in absolute terms a higher mass of 1,000 grains in the case of undersized grain formation corresponds to a higher level of agricultural engineering practice. Therefore, for introducing a correction for undersized grain formation we computed the mean values of the possible decrease in crop yield, which we recommend be used under the condition of appearance of the phenomenon of undersized grain formation (Table 3).

The investigations show that the phenomenon of undersized grain formation can be considerably lessened by an increase in the application of fertilizers on sown grain fields, the carrying out of sowing of winter crops only at optimum times, the use of optimum areas of fallow precursors with the sowing of winter crops, and the organization of harvesting in years of possible undersized grain formation by a separate method in the shortest possible time.

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UDC 551.465.75(470.23)

CALCULATIONS OF WATER SURGES AT THE MOUTH OF THE NEVA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 107-108

[Article by G. A. Kruglyak, Candidate of Geographical Sciences K. S. Pomeranets and E. N. Turuntayeva, Leningrad Division State Oceanographic Institute, submitted for publication 21 February 1978]

Abstract: The article presents the results of computations of three cases of dangerous water surges at the mouth of the Neva. The computation error for all the minimum and hourly levels does not exceed 20 cm, which is evidence of the possibility of using the hydrodynamic method for predicting surges.

[Text] Leningrad floods have long ago acquired wide reknown and their study and prediction is now being devoted considerable attention. However, inundations are only one of the manifestations of aperiodic level fluctuations which are observed in coastal seas. At Leningrad, in particular, in addition to inundations there are considerable decreases in water level, also disrupting economic activity. However, this phenomenon has not been especially examined in the literature, other than a study by A. I. Freydzon [4]. It is noted that considerable decreases in level are a result of atmospheric processes over a considerable area when the regions of reduced pressure are situated primarily in the southern part of the Baltic Sea. It is pointed out that a reliable method for predicting surges of water at the mouth of the Neva is yet to be developed.

Recently Leningrad inundations have been investigated by a hydrodynamic method based on numerical integration of one-dimensional equations for shallow water [1]. Tests were carried out of a method which includes computations of about 70 cases of real level rises, including 19 inundations at Leningrad above 180 cm during the last 30 years [2]. For checking the universality of the method and for practical purposes it was of interest to apply it to computations of considerable reductions in level at the Neva mouth.

Now we will examine three cases of water surges at the mouth of the Neva during the last 10 years: 22 September 1973, 9 October 1974, 20 November 1975, when the minimum levels attained the readings -90 cm, -116 cm and -103 cm respectively. The computations were made for 18 hours from the initial time, 6-8 hours prior to the onset of the minimum level. The method for computing the surges is completely similar to the computations of inundations and was applied using actual hydrometeorological information. We used observational data collected at shore stations in the Gulf of Finland and the Baltic Sea above the level at the initial moment and wind each three hours. Linear interpolation of these data was carried out on the longitudinal axis of the basin from the mouth of the Neva to the Danish Straits at points of intersection situated each 75-120 km. The value of the element at such an axial point was found using the formula

$$f_i = \alpha_A f_A + \alpha_B f_B ,$$

where f_A, f_B are the observed values of the element at stations A and B, situated on opposite shores of the basin on the same line with the interpolation point i; α_A, α_B are linear interpolation coefficients;

$$\alpha_A = r_B/r, \quad \alpha_B = r_A/r,$$

r is the distance between A and B, r_A, r_B is the distance from the stations to the point i.

The shearing stress of the wind over the sea was computed using the formula $\tau = 3.2 \cdot 10^{-6} W^2 \cos \beta$ (W is wind velocity in m/sec, β is the angle observed between the wind direction and the azimuth of the axis).

Table 1

Errors in Computations of Water Surges at Mouth of Neva

Дата (1)	(2) По минимуму		(3) По ежечасным уровням, см		
	Δ см	Δt ч (4)	$\bar{\Delta}$	$\lvert\bar{\Delta}\rvert$	σ
20 IX 1973	+13	+1,0	+4	11	14
9 X 1974	−3	+3,5	−5	13	16
20 XI 1975	+14	+2,0	+7	14	17

Key:

1. Date
2. For minimum
3. For hourly levels, cm
4. hours

The results of computations in comparison with level observations at Leningrad are given in Figure 1. The errors in computations of minimum and hourly levels, similar to the evaluations of computations of inundations [2, 3], are given in Table 1. For each case we determined the errors for the minimum Δ and the time of its onset Δt, the mean (of 18 hourly values) errors $\bar{\Delta}$, the mean absolute errors $|\bar{\Delta}|$ and the mean square errors σ.

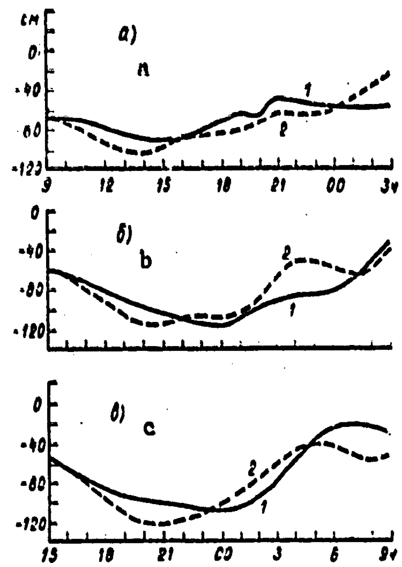

Fig. 1. Observed (1) and computed (2) levels at mouth of Neva during surges. a) 22 September 1973; b) 9 October 1974; c) 20 November 1975

It follows from the figure and table that the quality of the computations is quite satisfactory. The errors in computing each surge case with respect to any index, other than time of onset of the minimum, were almost half the computation errors in the four individual cases of inundations at Leningrad during recent years [3]. It can be postulated that the more satisfactory results of computations of surges in comparison with inundations are associated with different level changes with time during these phenomena. During surges the level changes considered here during an hour did not exceed 20 cm, whereas in the case of inundations, including those computed in [3], these changes were 50-80 cm. A smoother change in level with the existing three-hour discreteness of meteorological observations is reproduced better by numerical solution of one-dimensional equations for shallow water. With respect to the systematic error in computations at the time of onset of the minimum, it means that the actual minimum level sets in later than the computed level. This circumstance has a definite positive importance in prognostic respects. The source of this systematic error can be established using some numerical experiments. Their purposefulness, however, is not obvious, since all other errors in computing surges are small.

The results indicate that the hydrodynamic method can be applied not only to computations, but also to predictions of surges, the same as it is applied to predictions of inundations. Since predictions differ from computations only with respect to meteorological initial information, it is obvious that in the considered cases when there were satisfactory predictions of wind and surface pressure fields there was a possibility of satisfactory prediction of level decreases at the mouth of the Neva.

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UDC 551.461(261.35)(282.247.21)

MODELING OF SUPERPOSITIONING OF MAXIMA OF THE SEICHE LEVEL, WIND-INDUCED SURGE AND A LONG WAVE IN THE NEVA INLET

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 109-110

[Article by Candidate of Geographical Sciences V. G. Noskov, State Hydrological Institute, submitted for publication 18 January 1978]

Abstract: It has been established using large-scale hydraulic models of the Gulf of Finland and the Baltic Sea that with mutual superpositioning of seiche, long-wave and westerly wind-induced variations of water masses the resultant maximum rise in water level at the head of the Gulf of Finland is less than the sum of the individually taken variation components. An explanation of the reasons for this phenomenon is given.

[Text] When there are storm-induced level rises at the head of the Gulf of Finland, with some degree of arbitrariness it is possible to distinguish three principal types of rises: seiche, long-wave rises and rise due to surge of water masses under the influence of the westerly wind. Sometimes at the head of the gulf only one of the mentioned types of rises is noted, but more frequently there is a superpositioning of variations of two or all three types. In the course of the investigations of a hydraulic model of the Gulf of Finland for determining the mechanism of formation of sea inundations in the Neva delta we reproduced the mutual superpositioning of the mentioned types of level rises.

The Neva delta, Gulf of Finland and the northeastern half of the Baltic Sea proper were formed in a model constructed in a channel laboratory at the State Hydrological Institute in 1974. The horizontal scale of the model was 1:10,000 and the vertical scale was 1:200. The area of the model was 1,200 m^2. Long waves of different dimensions were reproduced by a special wave generator, wind-induced surges were produced by centrifugal fans mounted in sufficient number over the water surface of the model, and seiche variations developed in the model as a result of reflection of long-waves at the head of the gulf and had the nature of inertial, gradually attenuating variations.

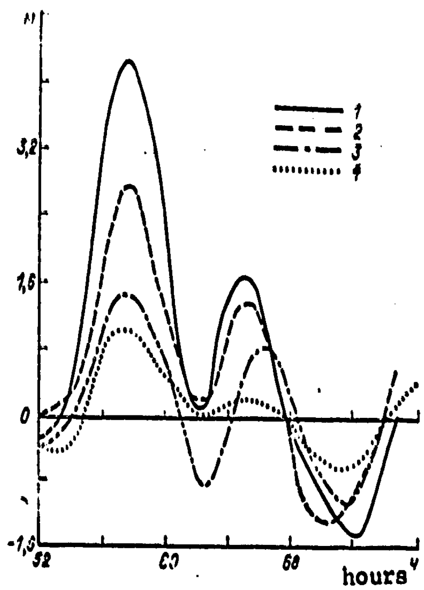

Fig. 1. Variation of water level in Neva delta with superpositioning of different types of level rises (model). 1) observed resultant level variation, 2) long-wave variations, 3) level variation caused by wind-induced surge, 4) seiche variation.

The height of the rise and the level variation were registered using automatic recorders of electric measuring equipment simultaneously at 20 stations in the model (1 in the Neva delta, 12 at the head of the gulf from the mouth of the Neva to Shepelevo and 7 in the remaining part of the gulf). As a control system we used special rules (rulers) which at these same points registered the maximum height of the water level rises with a mean square error of ±0.5 mm or ±10 cm for the natural scale.

In the course of the experiments we reproduced four combinations of superpositionings of different types of level rises:

a) rise due to the long wave running into the rise from the seiche;
b) rise from the wind surge "on top" of the rise from the seiche;
c) rise from the wind surge "on top" of the rise from the long wave;
d) rise from the wind surge "on top" of the rise from the long wave, which at the same time was superposed on the rise from the seiche.

The experiments were carried out in such a way that the maxima of the superposed rises coincided in time. With such superpositioning there was excitation of seiche oscillations giving level rises in the Neva delta of approximately 100 cm, wind-induced surges -- 150 cm and rises attributable to long waves -- 250 cm, that is, rises with an exceedingly rare frequency of recurrence, since in the case of higher rises the relative measurement error will be less.

An analysis of the experimental data indicated that the real picture of level variations in the case of mutual superpositionings of different kinds of irregular long-period variations differs from that which is assumed in computations made using well-known theoretical models. In particular, in almost the entire gulf from Tolbukhin beacon the magnitude of the resultant rise observed in the case of such superpositionings is equal to (or in any case is close to) the arithmetical sum of separately taken rise components. In the Neva delta and in the Neva inlet (including the northern and southern "gates") the resultant magnitude of the rises in the case of such superpositionings of phenomena is less than the sum of the components of these rises. In other words, at the head of the gulf there is no superpositioning of phenomena. No resonance phenomena were detected in experiments with superpositioning of phenomena.

Figure 1 shows an example of superpositioning of phenomena in the Neva delta for three simultaneous rises of different origin. In this case the resultant rise was approximately 17% less than the arithmetical sum of the separately taken rises. This phenomenon can arbitrarily be called level loss. Its approximate value for different combinations of superpositioning of phenomena in individual cases attains 20%.

The level loss in the case of superpositioning of a long wave on a seiche is attributable to the differences in the hydraulic conditions for propagation of the long wave: in one case it is propagated in an undisturbed water medium where there are no currents, and in another case, in a water medium which has first lost equilibrium and experiences seiche oscillations complicated by the peculiar plane outlines of the Baltic Sea and the great nonuniformity of depths. It goes without saying that in the second case the losses of wave energy will be greater than in the first case.

The magnitude of the wind surge (whose dependence on depth of the water body is known) with its superpositioning on a seiche or on a long wave probably becomes less because in this case the surge takes place with a depth which is increased as a result of the rise from the seiche or long wave. In addition, with a level increment there is an increase in the area of the water body, and therefore a definite volume of water mass, advancing in the head of the gulf with a higher initial level will give a lesser level increment than the same volume advancing with a lower level.

The level loss when there is a superpositioning of all three mentioned types of rises is evidently attributable to these same factors.

On the basis of numerous experiments carried out using our model of the Gulf of Finland and confirmed by experiments using another model of the entire Baltic Sea at a scale of 1:100,000 it can be assumed that the level loss phenomenon in the case of superpositioning of irregular long-period variations under similar topographic and hydraulic conditions has a general character and is characteristic not only of the head of the Gulf of Finland, but also the heads of other marine embayments, bays and estuaries, although without question the magnitude of the level loss, to a considerable degree dependent on their topography, will be different.

UDC 551.509.616

INVESTIGATION OF AN AIRCRAFT LIQUID GENERATOR OF ICE-FORMING AEROSOLS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 111-115

[Article by Candidate of Physical and Mathematical Sciences S. P. Belyayev, N. S. Kim and Yu. N. Matveyev, Institute of Experimental Meteorology, submitted for publication 29 March 1978]

Abstract: The article describes a model of an aircraft generator, the apparatus and method used in its testing. Also given are the results of determination of the ice-forming activity of aerosols of a number of reagents. Active aerosols were obtained either with the combustion of an acetone or morpholine solution of silver iodide or in the thermal sublimation of copper acetyl acetonate.

[Text] In the arsenal of modern means for the modification of supercooled clouds, in addition to antihail shells, rockets and pyrotechnic mixtures, use is being made of aircraft generators of ice-forming aerosols in which an active aerosol is formed with the combustion of solutions of silver iodide, for example, in acetone. Their use is justified by the fact that aircraft supplied with such generators can seed clouds of different areal extent with an active aerosol; the density of such seeding can be prestipulated. Aircraft generators are widely employed abroad and the literature describes the results of their testing both under natural conditions and in wind tunnels [5]. However, in our country they have not yet come into extensive use, for example, in wind tunnels. For the most part we employ pyrotechnic generators of ice-forming aerosols and generators operating on the explosive dispersion principle, but aircraft generators could be useful for many practical situations.

In this paper we describe the results of wind tunnel testing of a model of an aircraft generator. Three series of generator tests were carried out. In the first series of tests the active aerosol was produced by combustion of a 2% (by weight) solution of AgI in acetone; in the second series — with combustion of a 2% (by weight) solution of AgI in morpholine; in the

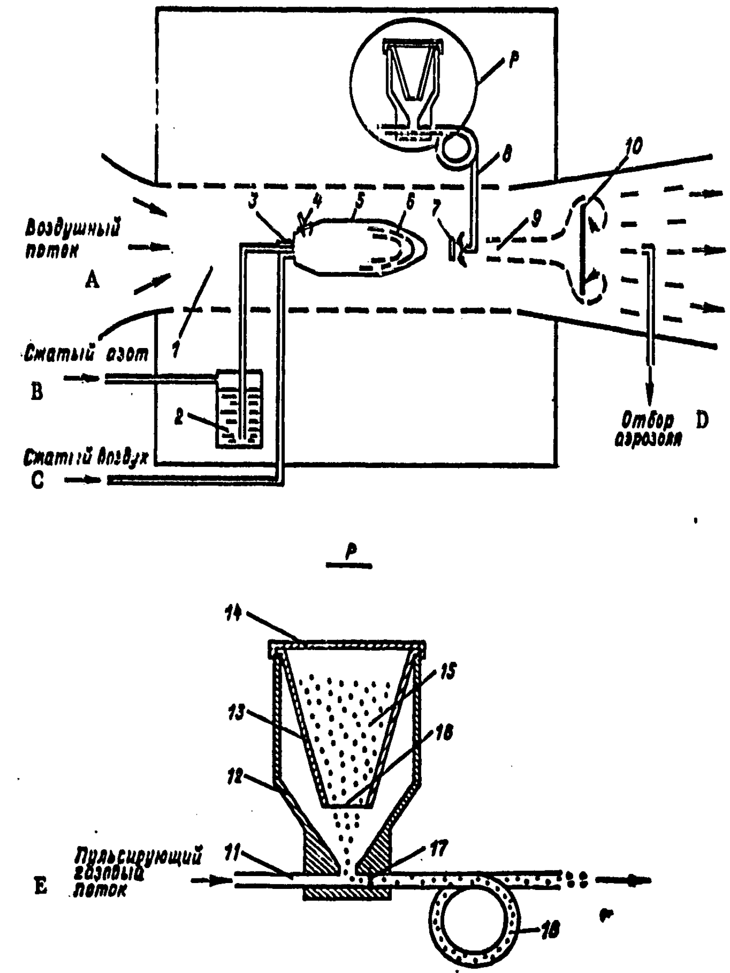

Fig. 1. Diagram of testing of generator of ice-forming aerosols.

Key:

A. Air flow
B. Compressed nitrogen
C. Compressed air
D. Outflow of aerosol
E. Pulsating gas flow

third series -- with thermal sublimation of pulverized copper acetyl acetonate.

The first series of tests with acetone solutions of silver iodide was carried out for the purpose of comparing the results obtained using our generator with the results obtained abroad in the testing of similar generators.

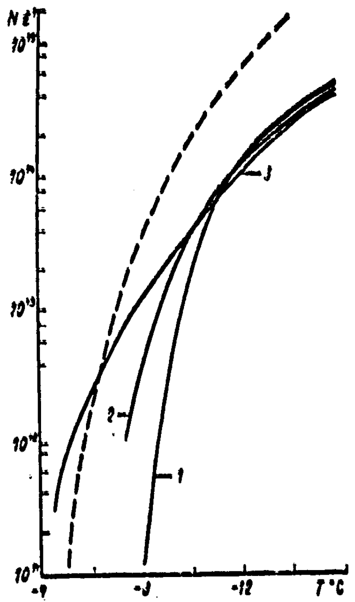

Fig. 2. Dependence of yield of active nuclei N on temperature T of supercooled fog. 1) combustion of acetone solution of AgI-KI; 2) combustion of morpholine solution of AgI; 3) thermal sublimation of pulverized copper acetyl acetonate. The dashed curve represents the theoretical Fletcher curve.

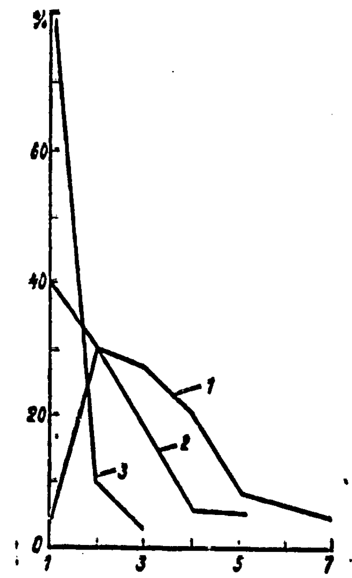

Fig. 3. Diagram of activity of ice-forming nuclei. 1) copper acetyl acetonate (thermal sublimation); AgI (combustion of acetone solution of AgI-KI); 3) AgI (combustion of pyrotechnic mixture).

In the second series of tests we investigated the possibility of obtaining an active AgI aerosol using an aircraft generator with combustion in it of an AgI solution in morpholine instead of the usually employed AgI-NH_4I, AgI-KI or AgI-NaI solutions in acetone. Morpholine is a colorless oily hygroscopic fuel fluid with a low viscosity and an ammonia smell. The chemical formula is C_4H_9NO. The density is 1 g/cm^3. A 2% silver iodide solution is obtained by the dissolving of a corresponding quantity of silver iodide in morpholine without any additives. The first communications on the use of morpholine without its joint use with AgI for the modification of cumulus clouds were given in a series of studies [4, 6, 7]. It was noted in [7], in particular, that there are facts indicating that some organic amines, among which morpholine is included, in small quantities can favor, or on the other hand, impede the formation of ice crystals.

In the third series we carried out an investigation of the possibility of using an aircraft generator for obtaining active aerosols of organic substances. In particular, we used copper acetyl acetonate as the reagent. The ice-forming properties of this reagent were discovered for the first time by Malkina and Patrikeyev [3, 9]. Copper acetyl acetonate is a powder of a blue color with particle sizes measuring several microns. Its chemical formula is $Cu(C_5H_7O_2)_2$. At a high temperature copper acetyl acetonate breaks down and loses its ice-forming properties. Therefore, in order to obtain a highly dispersed aerosol the thermal sublimation of the reagent must take place at temperatures which are considerably less than the temperatures within the aircraft generators. The developed model of an aircraft generator is easily transformed into a generator of copper acetyl acetonate aerosol if within the generator there is combustion, for example, of pure acetone and powders of this reagent are introduced into the low-temperature flame zones by means of a special sprayer.

Generator and method for its testing. The generator and a diagram of its testing are shown in Fig. 1. In the first two series of tests we combusted acetone or morpholine solutions of silver iodide. A solution of silver iodide is fed to a pneumatic nozzle 3 from the tank 2 under the influence of the pressure of compressed nitrogen, whereas air is fed from a compressed air line; as a result, in the combustion chamber 5 with a volume of 2.8 dm^3 there is a sprayed mixture of a fuel solution and air which is ignited using the sparkplug 4. Combustion of the solution causes formation of a stream 9 of highly disperse silver iodide aerosol. The expenditure of silver iodide was selected at the level 0.05 g/sec; this corresponds to the usual expenditure of reagent for aircraft generators and exceeds by several times the expenditure of reagent for ground generators [5].

In the third series of tests we combusted pure acetone for the thermal sublimation of copper acetyl acetonate in the generator. Copper acetyl acetonate was introduced into the flame zone 6 with a temperature of about 430°C by means of a special sprayer of measured quantities of the powder P through the line 8. The reagent was fed toward the flame plume. At some distance from this line there was a light screen 7 for preventing the reagent from entering the zone of higher temperatures, where its decomposition can occur. After thermal sublimation of the reagent and its subsequent condensation beyond the generator a stream 9 of highly dispersed copper acetyl acetonate aerosol was formed.

The sprayer for delivery of measured quantities of powder P which we developed is a modernized variant of the sprayer described in [8]. The detailed design of this sprayer is shown in the lower part of Fig. 1. In the housing of this sprayer 12 there is a hopper 13 having a grid bottom 16. The powder 15, which is to be sprayed, is loaded into this bin and the latter is covered with the lid 14. It is mandatory that there be a free space between the powder and the lid. A gas flow is fed through the entry line 11 into the powder sprayer; the pressure in this line fluctuates. The dosed feeding of the powder from the sprayer bin is accomplished by a pulsating change in pressure of the gas medium under the grid bottom of the bin and a pulsating change (with some phase lag) in gas pressure over the powder within the bin. For better spraying of the powder, at the beginning of the output line there is a diaphragm 17 and the line itself or a part of it is bent in the form of a ring 18.

The expenditure of the reagent powder from the sprayer is set by the area of the working section of the bottom of the bin, the size of the grid openings, the area of the diaphragm aperture, and the frequency and intensity of pressure pulsations in the gas flow.

In the sprayer there is a bin having an internal volume of 75 cm^3, an internal radius of the upper base 2.5 cm, and a lower base -- 1 cm. The grid openings in the bin measure 1.5 x 1.5 mm. The internal diameters of the entry and output lines were 6 mm. The pulsating change in pressure of the gas flow was ensured by use of a modulator installed in the compressed air line. With a frequency of the pulsations 2 Hz with an amplitude of about 1 atm the expenditure of reagent powder was 0.1 g/sec.

The method used in all three test series for the generators of ice-forming aerosols was identical and involves the following. The generator is mounted in an adjustable air flow I in a wind tunnel. During operation of the generator, behind it there is formation of a stream 9 of active aerosol that is mixed uniformly in the section of the tunnel by special agitators 10. At a distance of 5 m downstream from the agitator, a part of the aerosol is continuously removed through an intake tube; in case of necessity this aerosol is diluted by pure air. A definite volume of the aerosol sample is introduced into a chamber with a supercooled fog. The forming crystals are trapped on glasses and on the basis of the number of crystals observed in the microscope field of view, taking into account the characteristics of the employed apparatus, we ascertain the ice-forming activity of the reagent (yield of ice-forming nuclei from 1 g of reagent) for a stipulated operating regime of the generator. The test method is described in greater detail in [2].

Test results. In the tests the generator of ice-forming aerosols operated under conditions close to the natural operating conditions of the aircraft generator; this was achieved by its ventilation by an air flow having a velocity up to 60 m/sec. The greatest number of tests was carried out for an air flow velocity of 20 m/sec; therefore, in this article a comparison of results of tests of this generator is made only for this one velocity.

Figure 2 shows the results of all three series of generator tests in which we determined the yield of active nuclei N from 1 g of reagent as a function of temperature T of a supercooled fog.

Table 1

Генератор 1	Используемые растворы 2	Расход AgI, г/сек 3	Выход активных ядер с 1 г AgI при фиксированной температуре переохлажденного тумана 4		
			−8°C	−12°C	−16°C
5 Модель самолетного генератора, наши данные.	AgI, морфолин 7	0,05	$3 \cdot 10^{12}$	$1,3 \cdot 10^{14}$	$4,5 \cdot 10^{14}$
	AgI—KI, ацетон 8	0,05	$1,5 \cdot 10^{11}$	$1,4 \cdot 10^{14}$	$5 \cdot 10^{14}$
6 Самолетные генераторы [5]:					
Atmospherics, Inc.	AgI—NH_4I, ацетон	0,035	$9 \cdot 10^{10}$	$2,5 \cdot 10^{13}$	$1 \cdot 10^{14}$
NOAA B . .	AgI—NH_4I, ацетон	0,09	$7 \cdot 10^{12}$	$5 \cdot 10^{14}$	$9 \cdot 10^{14}$
NOAA B . .	AgI—NaI, ацетон	0,09	$2 \cdot 10^{12}$	$3 \cdot 10^{13}$	$7 \cdot 10^{14}$

Key:

1. Generator
2. Solutions used
3. AgI expenditure, g/sec
4. Yield of active nuclei from 1 g of AgI for fixed temperature of supercooled fog
5. Model of aircraft generator, our data
6. Aircraft generators
7. Morpholine
8. Acetone

The results of the first series of generator tests with its operation with acetone solutions are given in Fig. 2 (curve 1) and in Table 1. In addition, the table gives the results of similar tests of aircraft generators carried out by Garvey [5] using a wind tunnel. The aircraft generators operated using 2% AgI acetone solutions. The table shows that in the entire temperature range the yield of nuclei from 1 g of AgI for our generator approximately corresponds to the yield of nuclei for foreign aircraft generators. Thus, on the basis of the results of tests of a model aircraft generator which we developed it is possible to evaluate the effectiveness of aircraft generators of this particular type.

The results of the second series of generator tests, with its operation using a morpholine AgI solution, are also given in Fig. 2 (curve 2) and in Table 1. It can be seen that in the temperature range for a supercooled fog, -11 - -16°C, the ice-forming activity of AgI aerosols obtained by the combustion of acetone and morpholine AgI solutions virtually coincides. The difference is observed for the temperature range -7 - -11°C. In this temperature range the yield of active nuclei during tests of a generator with an AgI solution in morpholine exceeds the yield of active nuclei for tests of a generator with an AgI-KI solution in acetone (curve 1). For a temperature of -8°C this difference attains 20 times. However, in work with a morpholine solution there was found to be a number of shortcomings: more difficult ignition of the sprayed reagent in the combustion chamber and the formation of a thick encrustation on the internal surface of the combustion chamber. Therefore, for the time being this solution cannot be recommended for practical use without the development of applicable methods for its combustion, despite some advantages which it has in the high-temperature range.

In the third series of tests, as already mentioned above, the generator operated in a regime of production of a highly disperse copper acetyl acetonate aerosol. In order to ascertain the ice-forming activity of this reagent, a passage of vapor was first employed in a cold chamber for creating a model supercooled cloud; then the aerosol to be tested was introduced there and we calculated the number of precipitating ice crystals. The number of crystals was relatively small. With the repeated introduction of vapor into this same volume the ice crystals again formed, but in this case in a considerably greater number. Ice crystals continued to be formed in subsequent introductions of vapor, but each time their number decreased. Figure 3 (curve 1) illustrates these experimental data. Along the y-axis we have plotted the percentage of nuclei manifesting their activity after the corresponding introduction of vapor, and along the x-axis -- the number of the vapor introduction. As a comparison, on this same graph we have shown the dependences which we obtained when using a wind tunnel for investigating pyrotechnic compositions with AgI (curve 3 -- very rapid dropoff) and in an investigation of acetone solutions of AgI-KI, combusted in our generator (curve 2 -- slower dropoff).

These results of study of the ice-forming activity of copper acetyl acetonate aerosols confirm what was found earlier by other authors [1]: a strong sensitivity of aerosols of this reagent to brief supersaturations of water vapor.

The yield of active nuclei from 1 g of copper acetyl acetonate (see Fig. 2, curve 3), if it is calculated by first summing the number of nuclei manifesting their activity after each introduction of vapor, with a temperature of the model cloud -6°C, is $2.5 \cdot 10^{12}$, at -8°C -- $1.2 \cdot 10^{13}$, at -10°C -- $4 \cdot 10^{13}$, at -12°C -- $1 \cdot 10^{14}$, at -14°C -- $2 \cdot 10^{14}$ and at -16°C -- $4 \cdot 10^{14}$.

Thus, the results show that the presently used aircraft generators can be used for the sublimation of organic ice-forming reagents. This requires their insignificant modification; in particular, the sprayer of measured quantities of pulverized substances developed by the authors can be used for the spraying of reagents.

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UDC 556.535.6

INVESTIGATION OF PEBBLY CHANNEL SEDIMENTS IN RIVERS USING UNDERWATER PHOTOGRAPHY

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 115-117

[Article by Candidate of Geographical Sciences R. V. Lodina and A. I. Shtraukh, Moscow State University, submitted for publication 19 December 1977]

Abstract: The paper examines the use of an underwater photographic survey in a study of channel pebbly and bouldery sediment. The authors describe an apparatus for underwater photographic work. A method for carrying out work with an underwater photographic survey of the channel bottom is presented.

[Text] Many studies have been devoted to an investigation of channel deposits in mountainous and semimountainous rivers [1-3, 5, 6]. However, the conclusions and regularities defined by different researchers are based exclusively on materials from studies of the pebbles making up the shoals along the channel which emerge from beneath the water at low water. Data on the underwater part of the channel are lacking, which reduces the value of the results and limits the possibilities of their use. In addition, the content of pebbles of different particle size was determined in samples or in areas selected or laid out in the shoals along channels, on the basis of which it was possible to compute the mean diameter or other morphometric characteristics of the pebbles. The mapping of pebbly channel sediment in the channel with respect to their types, as has been done for lowland rivers with sandy alluvium (Lebedeva, Chalov [4]), has never been accomplished. Nevertheless, the solution of different problems related to channel sediments (construction of mountain reservoirs, stability of cuts in navigable rivers, etc.) requires more detailed data on their composition. Therefore, the Channel Expedition of the Soil Erosion and Channel Processes Problems Laboratory of Moscow State University, working on the Kirenga River (a right tributary of the Lena River), used an underwater photographic survey in a study of channel pebbly and bouldery sediments, which in combination with a complex of traditional methods for making investigations in shoals, made it possible to obtain valuable materials concerning the peculiarities of distribution of sediments along the entire channel of this semimountainous river in a reach with a length of 240 km. The average width of the channel here is 400-500 m; the mean annual water discharge is 644 m^3/sec.

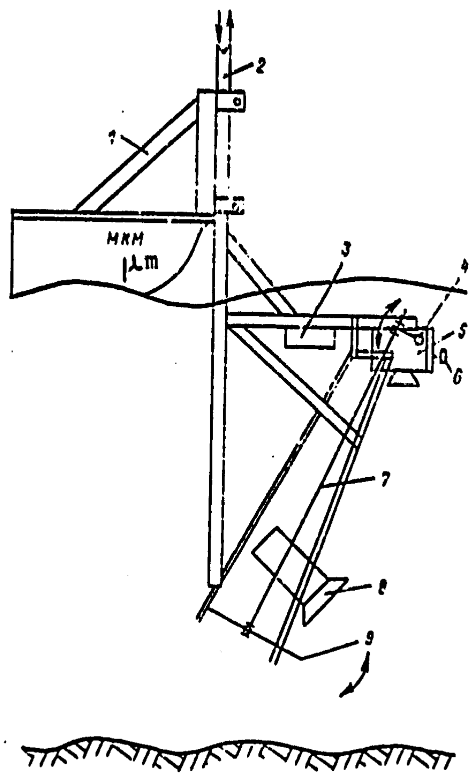

Fig. 1. Diagram of underwater photographic apparatus for survey of pebbly-bouldery alluvium for depths from 1.5 to 6 m for current velocity from 0 to 2.5 m/sec. 1) directing arm; 2) shaft; 3) unit for supplying current to flashbulb; 4) lever for camera shutter; 5) housing with camera; 6) handle for winding film; 7) rod for driving shutter lever; 8) camera flash bulb; 9) scale-lever for activating shutter

The most important characteristic feature in the morphology of the Kirenga channel is that it is highly branching (broken by islands and shoals into a great number of arms and subsidiary channels). The exceptional transparency of the water at low water in the Kirenga River channel (turbidity -- 0.0050 g/liter or less), when even at depths as great as 6 m it is possible to see almost every fragment and it is possible to carry out an underwater photographic survey of bottom sediments.

The investigation of the composition and distribution of pebbly alluvium was carried out in stages. In the first stage we made a granulometric determination of the granulometric composition of the surface layer of pebbles in shoals in areas measuring 1 x 1 m using the method described by Ye. I. Sakharova and N. V. Lebedeva [6]. An analysis of data from 200 sampling areas made it possible to formulate a classification of types of pebble deposits based on a predominance of the fractions within the limits of the sampling area. In the next stage we carried out photographing of these same areas on shoals with subsequent measurements of pebbles by fractions within the limits of each survey frame. With photographing of the sample areas there was adherence to the condition of verticality of the camera objective axis to the surface of the area by means of attachment of the camera to the tripod. A scale ruler was photographed as part of each frame. The discrepancy in the results of determination of direct measurements of the mean diameter of pebbles in an area and the results obtained by the processing of a photograph was not more than 10-15%. In this comparison it was found that the fractions of boulders, large and intermediate-sized pebbles are contained in approximately equal quantity both in the processing of photographs and in indirect measurements on shoals and there are some discrepancies for small pebbles only.

A comparison of the results of determination of the mean weighted diameter by the measurement and photographing methods made it possible to use a single method for the mapping of sediments along the entire channel and determining the mean diameter both for the parts of the channel above the water at shallow water and for the underwater parts. However, at different water levels the above-water shoals can be submerged below the water, and vice versa. Therefore, the method for determining the mean diameter of pebbles by the photographic method, developed for shoals, is applicable for the processing of underwater photographs.

An underwater survey of the channel bottom was carried out using an apparatus constructed by A. I. Shtraukh (Fig. 1). The operating principle for the apparatus was based on use of a camera hermetically isolated from the water medium. The survey was made under low water conditions. Precisely during this time a water thickness with a depth up to 6 m had a very high transparency. The current velocity in the river varied in the range from 0.5 to 2.5 m/sec. The proposed construction ensured the possibility of a survey at depths from 1.5 to 6 m. The upper range was limited by the maximum extent of the area taken in by the frame using a wide-angle objective with a focal length of 37 mm and constituting 0.8 m^2. The lower limit -- 6 m -- was the depth at which with daytime solar illumination there was a sufficiently good bottom visibility. The use of a synchronized photoflash hermetically isolated from the water medium makes it possible to use this apparatus independently of the intensity of solar illumination, which considerably broadens the possibility of a photosurvey of the channel bottom.

The apparatus for underwater photography is a framework-arm assembly in which is mounted a housing and a rigid coupling in the form of a special scale coupled to the camera shutter by a system of levers. At the moment of contact between the object to be surveyed and the special scale the camera shutter will be triggered. The support with the camera housing is mounted on a wooden shaft 6.5 m long fitted into a slot in the directing (guiding) arm. On this shaft there are graduations making it possible to ascertain bottom depth during the photographic work. The directing arm, mounted rigidly to the prow of the vessel, made it possible to maintain the verticality of the objective axis to the surface of the alluvial shoal, which excluded scale distortion in a case when the photographing was carried out with a small angle of inclination to the surveyed object.

The apparatus was mounted on a vessel of the "MKM" type with an outboard motor. Photographing was carried out along longitudinal runs with a distance between adjacent points of 50 m. The number of runs in the channel was determined by the width of the latter. The distance between runs was 50-100 m. A detailed survey was made in sectors of rapids; smooth sectors were investigated in less detail. The points of photographing of the channel bottom were registered on the plan instrumentally using two plane tables. In all, we obtained about 5,000 frames under water and 2,000 frames in the shoals.

The subsequent processing of the photographs was carried out under office conditions. On the photographs, using a scale grid for each fraction, mounted on a "Clara camera" cartographic instrument, we successively discriminated the pebble fractions. The discriminated fractions were outlined with ink and by means of a "Ladoga" electronic planimeter we ascertained the percentage content of pebble fractions of different sizes. Then we carried out computations of the mean diameter of the pebbles on the photograph. From the 300 photographs processed in this way we selected standards ("keys") for the visual determination of the types of pebbles on the photographs taken in great numbers. This determination was made by an inspection of the films on a "Mikrofot" instrument and by a comparison of each frame with the standard for a particular type of pebbles.

The bottom material survey made gave us the possibility of compiling a map of the distribution of channel pebbly sediments in the channel of a semi-mountainous river; this is of very great importance for an analysis of the conditions for channel formation, computation of its stability, discrimination of zones of predominant erosion or accumulation of alluvium during channel-forming discharges, determination of noneroding velocities, etc. In addition, the results of mapping of bottom materials in sectors of rapids are very important in the planning of bottom-deepening work.

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FIFTIETH ANNIVERSARY OF THE ROSTOV WEATHER BUREAU

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 118-119

[Unsigned, submitted for publication 13 March 1978]

[Abstract: The article briefly discusses the history of development and results of work of the Rostov Weather Bureau.]

[Text] The Northern Caucasus Kray Weather Bureau, as it was then called, began its operations at Rostov-on-Don in February 1928. This was the first tiny weather service institute on the Don and its mission and its task included the supplying of meteorological information and forecasts to the workers of the Northern Caucasus Railroad, airlines, agriculture and the fishing industry in the Sea of Azov. Weather information was sent to the bureau only twice a day by telegraph from several tens of meteorological stations in Severo-Kavkazskiy Kray, and from adjacent territories -- by radio from the Moscow Meteorological Center.

The first weathermen (physicists) at the bureau were N. K. Krylov, Professor P. M. Yerokhin, F. L. Monoszon; I. V. But, V. A. Dzhordzhio, V. P. Dubentsov and others arrived somewhat later.

In those years it was difficult for Rostov meteorologists: there was a lack of actual information on weather from outlying areas, a lack of technical facilities and equipment, a shortage of the necessary specialists; methods for foreseeing the weather were not developed; local peculiarities of atmospheric circulation and weather were not known. But the years passed and there was a growth and improvement of the weather service in the country, including on the Don. In the 1930's Rostov weathermen began to use so-called frontological analysis of synoptic processes, proposed by the Norwegian school of weathermen and later improved by Soviet meteorologists. In this respect much was done by the former chief of the Rostov Weather Bureau, now Professor I. V. But. These and other scientific innovations considerably increased the quality of all the meteorological information, including weather forecasting.

In the early 1930's two related services were established in the weather bureau: hydrological forecasts and agrometeorological information ("yield services"), whose purpose was the routine collection and dissemination to interested organizations of information on the state of rivers and hydrological forecasts, on changes in the state of sown agricultural crops in relation to weather conditions. For the same reasons as for weathermen, it was difficult for hydrologists and agrometeorologists. And nevertheless the modest information which they collected and the forecasts which they prepared enjoyed a great demand from water and agricultural organizations.

During the war years the work of the Rostov Weather Bureau was briefly interrupted, after which a qualitatively new stage began in its history. This was characterized by the rapid technical and scientific growth of all its services. During this period the specialists in all fields created more than 130 scientific and methodological innovations for predicting the elements of the hydrological regime of water bodies, most weather phenomena and agrometeorological indices. Some of these scientific studies, such as predictions of water inflow into Tsimlyanskoye Reservoir, hurricanes and the choice of the optimum times for the sowing of winter wheat, received a high evaluation at scientific organizations and their authors (I. M. Chernoivanenko, N. K. Parshina, I. V. Svisyuk) were awarded the academic degrees of Candidates of Sciences.

In the everyday work of weathermen they introduced new, computation methods for predicting almost all weather parameters, which considerably objectivized the preparation of forecasts. During the postwar years weathermen received the most modern equipment: electronic computers, meteorological earth satellites, surface radiometeorological radars, high-speed radiotelegraph and facsimile apparatus, automatic transponders, etc. The introduction of new weather forecasting methods, local scientific developments and techniques had an appreciable effect on increasing the quality of short-range weather forecasts. For example, whereas in the 1950's their mean probable success was 78-80%, during the last five years it has been 84-86%. Weathermen have learned relatively well how to predict marked warmings, coolings, freezings, strong winds, blizzards and frontal continuous precipitation. But it is still difficult to predict such phenomena as local summer heavy showers, hail falls and squalls.

Due to the great amount of research work, there is a firmer scientific basis for the hydrological and agrometeorological forecasts, the probable success of which is now 85-95%, and for short-range forecasts of water levels in rivers -- 98-100%. The mean rayon yields of winter and some spring crops are predicted with a period 1.5-2 months in advance with an error of not more than 5-10%. The agrometeorologists of the 1930's could only dream about this.

Over a period of 50 years the Rostov weather bureau has introduced a major contribution to socialist construction in the Northern Caucasus and on the Don. Advance warnings of dangerous and especially dangerous hydrometeorological phenomena always served as an acute signal for the taking of some emergency measures for preventing or reducing material losses from the action of meteorological phenomena. During the last three years alone the economic effect from the use of hydrometeorological information, forecasts and warnings, according to preliminary data, was about 27 million rubles.

A particularly great economic effect is obtained from economic measures taken on the basis of the warnings of hydrologists concerning anticipated floodings of the floodplain along the mouth sector of the Don when the waters are driven by the wind, long-range forecasts of the inflow of water into Tsimlyanskoye Reservoir, warnings of weathermen with respect to sharp coolings, frosts, forecasts of agrometeorologists concerning spring supplies of soil moisture, results of wintering of winter crops and grasses, concerning optimum times of sowing and yields of agricultural crops, and also different kinds of recommendations on agricultural te hniques and equipment to be used, such as may be indicated by the curr..it and expected agrometeorological conditions.

Now a large staff of specialists is working in the weather bureau. For the most part these are young, knowledgeable, work-loving people: V. A. Kirnos, L. I. Malygonova, N. Ye. Veremeyenko, N. K. Parshina, V. A. Vasil'yeva, and others, who are carrying forward the work of service veterans -- Ye. F. Goncharova, N. S. Taran, A. V. Zarevskaya, A. I. Durasova, I. M. Chernoivanenko, N. S. Dvurechenskaya and R. G. Yeritspokhova.

We are also proud of the scientists who have now gone from our weather bureau, those from whom we acquired a love for creative work: Corresponding Member USSR Academy of Sciences Ye. N. Blinova, Doctors of Sciences I. V. But', V. R. Dubentsov, V. A. Dzhordzhio, A. D. Zamorskiy, L. S. Minina, Candidates of Sciences S. A. Malik, A. M. Basin, all of whom have made a considerable contribution to the development of hydrometeorological science.

In the coming years Rostov hydrometeorologists and agrometeorologists are anticipating new scientific research and more modern and higher-speed computers, by means of which it is planned to carry out new and improve old numerical programs for short-range weather forecasting and especially showers, thunderstorms, hail, precipitation and also long-range forecasts of individual elements of the hydrological and agrometeorological regime. In this way still another step will be taken on the path to highly accurate computed hydrometeorological forecasts.

REVIEW OF MONOGRAPH BY A. N. POLEVOY: AGROMETEOROLOGICHESKIYE USLOVIYA I PRODUKTIVNOST' KARTOFELYA V NECHERNOZEM'YE (AGROMETEOROLOGICAL CONDITIONS AND PRODUCTIVITY OF POTATOES IN THE NONCHERNOZEM ZONE), LENINGRAD, GIDROMETEOIZDAT, 1978, 118 PAGES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 120-121

[Article by Candidate of Geographical Sciences M. S. Kulik]

[Text] This reviewed book by A. N. Polevoy generalizes the experiences in agrometeorological support of potato production. It examines recommendations on the cultivation of potatoes, taking into account the developing agrometeorological conditions, which is of particularly great importance for the Nonchernozem zone. In this zone plans called for the consolidation of existing and the organization of new specialized vegetable and potato farms, the expansion of potato cultivation near industrial centers.

Agrometeorologists have published a number of studies devoted to the problems involved in evaluating the correspondence between the climatic conditions in different regions in our country and the biological peculiarities of the potato crop and methods for evaluating and predicting agrometeorological conditions for the formation of the yield of this crop. First of all we should mention the studies of A. N. Rudenko -- VLIYANIYE ZASUKHI NA UROZHAY KARTOFELYA (Influence of Drought on the Potato Yield) (1958), O. M. Popovskaya -- METODIKA OTSENKI AGROMETEOROLOGICHESKIKH USLOVIY PROIZRASTANIYA KARTOFELYA V TSENTRAL'NYKH OBLASTYAKH YeTS (Methods for Evaluating Agrometeorological Conditions for the Cultivation of Potatoes in the Central Oblasts of the European USSR)(1957), Ye. A. Tsuberbiller -- PUTI POVYSHENIYA UROZHAYNOSTI KARTOFELYA (Ways to Increase Potato Yields) (1969) and others. The importance of these studies for the agrometeorological support of potato cultivation is very great. However, during the last decade there has been a substantial increase in the level of agricultural engineering in the cultivation of potatoes, new varieties have been introduced, the large-scale use of mineral fertilizers was begun, the use of more effective means for contending with potato crop diseases and predators has been ensured. All this requires the improvement in the agrometeorological support of potato cultivation.

New types of agrometeorological observations (contactless measurements, aerial investigations, etc.) make it possible to broaden and deepen agrometeorological servicing.

The book by A. N. Polevoy is the first attempt at filling the gaps in the literature concerning the new requirements on agrometeorological support of potato cultivation and the present-day possibilities of agrometeorological predictions and computations applicable to the potato crop.

The book examines problems characterizing the object of the investigation, the influence of environmental factors on the growth, development and productivity of potatoes, the problems of prediction of yields for different times in advance; the author gives an evaluation of the possible yield losses during harvesting in connection with the unfavorable weather conditions; there is a discussion of the spatial-temporal variability of the potato yield.

The author has succeeded in bringing together fragmentary studies on the evaluation and prediction of the agrometeorological conditions for the formation of the potato yield in the Nonchernozem zone.

The first two chapters of the book set forth the methods for evaluating the state of potato plantings and determination of the phases of development over great areas by means of aerophotometric measurements, as well as methods for predicting the phases of potato development.

In examining the rates of formation of individual plant organs, the author in sufficient detail dwells on the great importance of the rates of development for crop yield. Chapter III gives a critical generalization of existing methods for predicting the moisture supply of potato plantings and evaluating the current and predicted conditions for yield formation.

The principal content of Chapter IV is an analysis of the influence of meteorological conditions on formation of the potato yield: on this basis the author has proposed a method for predicting the mean potato yield for a territory (rayon, oblast). Also given is an evaluation of the possibility of predicting the random component of the time series for the mean oblast potato yield; also given is a quantitative evaluation of the dynamics of the mean oblast yield through the temporal change in the structure of the influence of environmental factors characterizing both agrometeorological conditions and the agricultural techniques and equipment used in cultivation.

For the long-term planning of the development of agricultural production it is necessary to predict the crop yield level for the years immediately ahead. The possibilities of such prediction are set forth in Chapter V.

Chapter VI describes methods for evaluating agrometeorological conditions during a period of harvesting; it gives the characteristics of the dependence of losses of tubers during harvesting due to unfavorable weather conditions. Chapter VII examines the spatial-temporal variability of the yield of potatoes in relation to the peculiarities of climate of the Nonchernozem zone. In the Nonchernozem territory the author has discriminated zones of different climatic variability of the yields of potatoes and computations of synchronous variations of yield have been made.

An evaluation of the spatial and temporal variability of potato yields was supplemented by data characterizing the degree of favorable agrometeorological conditions for the harvesting of tubers.

The book is not without its shortcomings.

Now there are different approaches to a quantitative description of the influence of environmental factors on the productivity of cultivated plants. For this purpose the author has made extensive use of the methods of mathematical statistics. However, the book does not include work done by the author on creating a dynamic model of formation of crop yield. One such model was published by the author. The use of dynamic models for the development of methods for evaluating the conditions for the formation of the productivity of agricultural crops is an extremely promising approach to the evaluation and prediction of agrometeorological conditions. The creation of dynamic models remains unmentioned by the author. In developing methods for predicting the potato yield it is necessary to take into account the importance of the variety structure of potato plantings for the mean oblast yield in years with different moistening conditions and also a possible decrease in crop yield due to damage by predators and diseases.

In general, the book merits a high evaluation. Without question, it will be read by specialists with interest and profit.

SEVENTIETH BIRTHDAY OF ALEKSEY NIKOLAYEVICH LEBEDEV

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 p 122

[Article by a group of comrades]

[Text] On 8 July 1978 Doctor of Geographical Sciences Aleksey Nikolayevich Lebedev, one of the leading scientists in the field of climatology, marked his seventieth birthday.

Aleksey Nikolayevich dedicated almost forty years of his life in the service of climatology.

In 1939, after graduation from Leningrad State University, he began his work activity at the Main Geophysical Observatory. In October 1940 he entered the ranks of the Red Army and participated in the war with the Belofinns and in the Great Fatherland War. For his defense of the motherland he was awarded the Order of the Fatherland War (second degree) and many combat medals. After demobilization Aleksey Nikolayevich became a graduate student at the Main Geophysical Observatory, from which he graduated in May 1947.

Since 1950 A. N. Lebedev has continuously headed the Earth Climatography Section of the Division of Applied Climatology at the Main Geophysical Observatory. He was the initiator in creating a series of studies on the climate of the USSR which constitute a multivolume description of the climate of our country. This series of studies was carried out under the direction and with the personal participation of Aleksey Nikolayevich. He invested considerable work in preparation of the SPRAVOCHNIK PO KLIMATU SSSR (Handbook on the Climate of the USSR).

A distinguishing characteristic of all his scientific investigations is an inseparable relationship to the needs of the national economy.

The monograph PRODOLZHITEL'NOST' DOZHDEY NA TERRITORII SSSR (Duration of Rains in the Territory of the USSR) is of broad scientific and practical importance; it received great praise from planning and construction organizations in the country.

He has played a major role in the writing of monographic studies on the earth's climate. Due to his inexhaustible energy and creative enthusiasm Soviet climatology has been enriched with major works on the climates of the continents.

The climatography of the earth created at the the Main Geophysical Observatory under the direction of A. N. Lebedev can serve as an example of scientific and practical research.

His work PARAMETRY TROPICHESKOGO KLIMATA DLYA TEKHNICHESKIKH TSELEY (Parameters of Tropical Climate for Technical Purposes) received merited recognition among many design and scientific research organizations.

In all his research studies Aleksey Nikolayevich devotes particular attention to meteorological problems -- he is constantly refining, working on and improving research methods.

The multisided scientific activity of Aleksey Nikolayevich has been highly recognized by the Party and the government: he has been awarded the order "Badge of Honor" and the medal "For Illustrious Work."

He willingly shares his rich experience and knowledge with his students. Under his direction many graduate students have successfully defended their candidate's dissertations.

The broad vision of the scientist-communist, the deep ideological conviction, the businesslike approach to solution of the arising problems, his dedication and devotion, brought him the love and respect of all his colleagues and students. Nikolayevich Lebedev meets his 70th birthday full of strength and creative thoughts.

In congratulating Aleksey Nikolayevich on his noteworthy birthday, we wish him good health and new creative successes.

WORK OF THE ALL-UNION SEMINAR SCHOOL OF YOUNG SCIENTISTS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 122-126

[Article by Sh. A. Musayelyan]

[Text] An All-Union Seminar on the Problem "Numerical Modeling of Large-Scale Atmospheric Processes and Long-Range Weather Forecasting" was held during the period 17-30 October 1977 at Dilizhan (Armenia). Such a seminar was carried out for the first time and it is assumed that it will be held periodically.

The seminar school was attended by more than a hundred speakers, reporters and auditors. There were two discussions on the subjects: "The Predictability Problem" and "Physical and Mathematical Difficulties in Long-Range Weather Forecasting."

The subject matter of the seminar school included the following matters: 1) Methods for long-range weather forecasting; 2) Modeling of large-scale atmospheric-oceanic processes, general circulation of the atmosphere and climate; 3) Energy aspects of the earth-atmosphere system. Boundary layer of the atmosphere. Parameterization of nonadiabatic factors; 4) Predictability problem; 5) Problem of aerometeorological and hydrophysical information.

The experience in modeling of the process of formation of the homogeneous layer of the ocean on the basis of integration of the equations of hydrothermodynamics, very important for long-range weather forecasting, was the subject of a joint report by Academician G. I. Marchuk, V. P. Kochergin, V. I. Klimuk and V. A. Sukhorukov entitled "Mathematical Modeling of Turbulence in the Surface Layer of the Ocean." The report dealt with the problems involved in the mathematical modeling of turbulent transfer processes in the world ocean within the framework of semiempirical theories. Emphasis was on investigation of the upper turbulent layer of the ocean. Using the concept of the coefficient of turbulent viscosity, the authors have constructed a model consisting of two energy equations: the energy of turbulence and the rate of turbulent dissipation. The coefficient of turbulent viscosity is determined by a simple algebraic expression. Using the proposed turbulent model, the authors examine the physical aspects of formation of the homogeneous layer in the ocean. On the basis of the solations obtained for the surface turbulent layer in the ocean, using the energy equations the authors validate the Obukhov formulas in combination with the concept of the Prandtl mixing length for the coefficient of turbulent viscosity. The seasonal variability of the turbulent layer generated by the model was surveyed on motion picture film. The information obtained in the course of the numerical experiment was fed out to a microfilming machine of the Karat type, connected to a BESM-6 electronic computer, using a system for the mathematical support of graphic devices developed at the Computation Center Siberian Department USSR Academy of Sciences. As an illustration of the solution the authors showed a motion picture film of the evolution of the surface layer over the ocean surface.

In his extremely interesting report entitled "Nonlinear Models in Problems in Geophysical Hydrodynamics" Academician A. M. Obukhov pointed out that at this stage in the development of the problem of general circulation of the atmosphere and weather forecasting it is extremely productive to examine simplified models with few parameters. The latter are obtained by expanding the fields in some system of "control" functions and approximation of the equations of hydrodynamics by a finite-dimensional system of differential equations by the Galerkin method. However, it is necessary that there be retention of the most important characteristics of atmospheric movements, the most important of which is the quadratic nonlinearity of the equations. As is well known, in 1969 A. M. Obukhov introduced the concept of systems of the hydrodynamic type (SHT), such dynamic systems for which: 1) the phase space is finite-dimensional; 2) the phase volume in the process of motion is conserved; 3) the equations of motion are quadratically linear; 4) there is at least one quadratic positively determined integral of motion (energy). SHT are convenient models for study of hydrodynamic instability, evidently being one of the factors causing a sudden change in the weather regime. They demonstrated the results of numerical and laboratory experiments for modeling of both the simplest SHT and multieddy currents which are described by chains of the cascade type. It is demonstrated that depending on the external parameters the system can be in different stationary states (characterized in the experiment by different inclinations of the eddy axes) and under the influence of different types of noise or carefully applied external force or removal of the latter can undergo transition from one state to another.

A group of reports was devoted to the development of ideas and theoretical developments of G. I. Marchuk on the application of the conjugate equations of hydrothermodynamics of the atmosphere-ocean-continent system to the problem of long-range weather forecasting.

For example, in a report by Yu. N. Skiba, for the purposes of predicting temperature anomalies for periods of up to a season, the author proposed a hydrodynamic model, using as the prognostic equation the law of conservation of thermal energy in the atmosphere, the world ocean and in the soil of the continents. The model assumes the wind velocity in the atmosphere and the velocity of currents in the oceans to be known and takes into account the radiation influxes of heat to the earth's surface. For the considered formulation of the problem use is made of the theorem of existence and uniqueness of the generalized solution.

The method for computing the temperature anomalies uses a solution of the formulated conjugate problem obtained in a definite way.

A report by V. P. Sadokov and D. B. Shteynbok examined the thermal conductivity equation for mean temperature, for which the conjugate equation is written. In particular, an evaluation was made of the contributions of different factors to the temperature anomaly (circulation, influence of the ocean, other types of heat influx). Some prognostic possibilities of the method were discussed.

V. P. Sadokov and A. I. Vazhnik presented the principles of a method for numerical forecasting for average times for the fields of the 500-mb isobaric surface for the northern hemisphere based on an integration of a system of conjugate equations in hydrodynamics.

In a large group of reports there was a discussion of problems important in developing methods for long-range weather forecasting; these related to the parameterization of large-scale nonadiabatic factors and processes transpiring in the atmospheric boundary layer.

D. L. Laykhtman, in a review lecture, pointed out that at the present time, in accordance with a description of the effects of turbulence, four models have been developed: a) the K-theory with an a priori stipulation of the turbulence coefficients, b) the nonlinear K-theory, c) semiempirical theory, d) a theory based on integration of unsmoothed equations with parameterization of the high-frequency part of the turbulence spectrum. However, the nonlinear K-theory is a rational description of the boundary layer, satisfactory with respect to the required accuracy and corresponding to modern capabilities of computers. An important part of the problem in general is the construction of a "splicing" of processes in the boundary layer with processes in the free atmosphere and also a "splicing" of the planetary boundary layer of the temperate latitudes with the boundary layer of the equatorial region.

Ye. M. Feygel'son discussed important problems in ideology and practical methods for taking into account radiant heat exchange in general circulation models. It was shown that when taking radiant heat exchange into account in general circulation models there must be adherence to the following principles: 1) The values necessary for computing radiation must either be reduced to parametric form using the characteristics generated by the general circulation model or be stipulated by special models. 2) The radiant fluxes must be expressed in explicit form through the parameters of the principal radiationally active anthropogenic substances. 3) The algorithms for computing the radiant fluxes must in explicit form contain cloud parameters. The speaker dealt in greatest detail on the process of functioning of the integral albedo of the atmosphere-underlying layer system.

Sh. A. Musayelyan, A. D. Tavadyan and Ye. M. Chechetkina, on the basis of earlier investigated asynchronous relationships between anomalies of the cloud cover over the ocean and deviations of air temperature over the continent from the norm, proposed a method for dynamic-statistical parameterization of the process of the thermal effect of the hydrosphere on the atmosphere.

A report by N. N. Kol'chitskiy, K. I. Maslov, Sh. A. Musayelyan and Ye. M. Chechetkina was devoted to an investigation, employing a very simple hydrodynamic model, of the contribution of convective heat transfer of the ocean to the formation of the atmospheric temperature field. As the lower boundary condition at sea level use was made of data on the anomaly of convective heat transfer, computed using the G. N. Mileyko method. Also examined were the prognostic aspects of the problem.

T. G. Berlyand devoted his report to a climatological description of the distribution of cloud cover over the earth. It was pointed out by the speaker that as a result of a climatological generalization of the accumulated observational data for the land and ocean it has been possible to refine and deepen our ideas concerning the cloud cover regime in different parts of the earth.

A number of reports dealt with spectral methods for investigating the dynamics of large-scale atmospheric processes. For example, a report by Corresponding Member USSR Academy of Sciences G. P. Kurbatkin and V. N. Sinyayev was a discussion of a spectral dynamic-statistical model of prediction of the pressure field up to seven days in advance. The basis for the model is the idea of "stabilization" of ultralong waves using statistical determined sources. Nonadiabatic factors are included differentially, in dependence on the scales of movement. The report gave a method for Fourier computations of the components of nonlinear terms of the equations, making it possible to reduce to a minimum the expenditures of computer time in the integration of the prognostic system. Also discussed was the problem of the "optimum" basis to be used in spectral formulation of problems in a quasi-solenoidal approximation. The paper gave some results of experimental tests of a prognostic eight-level model for a time up to seven days.

S. A. Mashkovich, in his report, dealt briefly with the history of development of linear spectral prognostic models. The speaker examined the principal spectral methods for solving nonlinear prognostic equations. Information is given on modern spectral models with use of full equations, on experience with long-term integration of spectral models, and on routine use of spectral prognostic models.

I. G. Veyl' described a spectral quasisolenoidal model based on use of series in spherical functions and the use of interaction coefficients. Also discussed were the results of numerical experiments carried out for the purpose of studying the influence of waves of a subgrid scale on the evolution of large-scale circulation components.

In the work of the seminar-school much attention was devoted to statistical methods of analysis and a long-range forecasting of meteorological fields.

G. V. Gruza proposed a multiaspect classification of statistical long-range forecasting methods and methods for the joint use of numerical hydrodynamic forecasts with statistics. The speaker analyzed the present status of use of statistical automated forecasts in the United States and discussed the prospects for increasing the advance time of forecasts and the problems involved in evaluating the predictability of empirical-statistical methods. The author examined problems relating to the formulation of forecasts in stochastic form, methods for evaluating their information content, quality and feasibility of practical use.

In another report by the same author a study was made of the problem of taking into account information on climatic trends during long-range forecasting. The author discussed some statistical multifactor models of meteorological processes, which are used for a quantitative evaluation of variability factors. The paper dealt with the problems involved in evaluating the information content of smoothed temperature characteristics, and in addition --- possibilities of extremal climatic trends and their use in long-range forecasting.

A report by E. Ya. Ran'kova was devoted to a method for the statistical forecasting of weather with application of the principle of group similarity and possible aspects of its use in meteorology.

Methods for evaluating the success of forecasts were covered in a report by L. S. Gandin. The use of correct methods for evaluating the success of forecasts is of great importance in developing methods for making weather forecasts, especially long-range forecasts. The use of inadequately sound evaluations not only favors false ideas concerning the success of forecasts, but can also lead to the evolution of forecasting methods in an incorrect direction. The success of the method for making forecasts in the servicing of specific users must be evaluated using economic criteria. The report gave examples of such evaluations.

During the work of the seminar school there was repeated discussion of problems relating to the predictability of atmospheric processes. For example, a report by M. I. Fortus was devoted to the statistical predictability of climatic changes. The speaker proceeds on the assumption that climate is a realization of a stationary random process and considers the problem, arising in such a case, of finding such linear functionals of the values of meteorological elements which can be predicted with a minimum mean square error from the values of these elements "in the past." For the considered processes it was possible to obtain the best predictable characteristics and the corresponding mean square forecasting errors.

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In a joint report by R. M. Dzhabar-Zade, Ye. M. Dobryshman, M. M. Fortus and Ya. M. Kheyfets the authors used statistical methods in examining the problem of interaction between the hemispheres, and in particular, the problem of air exchange between the northern and southern hemispheres.

In the work of the seminar-school attention was devoted to the problem of processing and use of aerometeorological and hydrophysical information. In a joint report by Corresponding Member USSR Academy of Sciences K. Ya. Kondrat'yev and O. M. Pokrovskiy there was examination of the following problems: present status of the global observation system from the point of view of the interests of long-range weather forecasts and the prediction of climate; the relationship between ordinary and satellite meteorological information; validation of satellite data and clarification of their value for the prediction of weather and climate. Particular attention was devoted to the problem of the information content of data from space remote sensing and optimum planning of application of remote sensing methods. The report gave a concise review of investigations with remote methods for determining parameters of the atmosphere and the underlying surface, necessary for long-range weather forecasting and climate predictions.

A report by V. V. Penenko was devoted to the problems involved in the use of actual information in numerical models of the dynamics of the atmosphere. The speaker reported on some numerical methods for solving problems in the analysis and assimilation of hydrometeorological information, as well as its assimilation and use in models of atmospheric dynamics. The basis for these methods is variational principles, the splitting method and the methods of the theory of perturbations and optimization methods. Specifically, the problem requires that the information be employed for evaluating and adjusting the parameters of the models described by systems of nonlinear differential equations in partial derivatives. With an uninterrupted receipt of information one of the proposed "adjustment" schemes realizes a feedback between the changes in the state of the system and is preferable in diagnostic investigations of the model.

A report by L. S. Gandin examined methods for the numerical modeling of observation systems.

There are two fundamentally different approaches to the modeling of observation systems: statistical and dynamic. The speaker presented the methodology of the two approaches, gave a brief outline of their development, and cited a comparison of their advantages and disadvantages. The statistical-dynamic approach proposed recently by N. Phillips was also described.

The speaker noted that among the different types of new observations existing at the present time the most promising is the indirect sounding of the atmosphere from satellites. In this connection, the report gave a detailed examination of the methods and results of evaluation of observation systems, including indirect sounding.

The problems involved in the introduction of the results of scientific research into practical work were given primary importance in the work of the seminar-school. In this connection leading specialists in the field of practical weather forecasting were invited to attend. Thus, the fundamental principles of preparation of a monthly weather forecast were presented in a report by N. I. Zverev. The speaker emphasized that during recent years in the process of preparation of a monthly weather forecast great attention is being devoted to the role of the underlying surface. Most of the time-consuming work of forecasters is being accomplished using electronic computers. For these purposes it has been possible to develop similarity criteria for the compared meteorological fields.

A report by G. G. Gromova examined the dependence of the success of 3-10-day weather forecasts on the quality of schemes for hydrodynamic forecasting of the pressure field. His paper presented examples of the use of numerical forecasts and mentioned the importance of their further improvement.

A number of reports were devoted to the modeling of oceanic processes.

For example, A. S. Sarkisyan, D. G. Seidov, D. G. Rzheplinskiy and V. N. Drozdov, in their joint report, examined the problem of modeling of large-scale circulation of waters in the world ocean.

A report by V. I. Kalatskiy discussed the problems involved in long-range forecasting of the thermal structure of the active layer of the ocean, the basis for which is the equation of motion, thermal conductivity equation and equation for the balance of turbulent energy. The speaker demonstrated experimental forecasts of the spatial distribution of the thickness and temperature of the quasihomogeneous layer in the North Atlantic in the summer of 1976 and analyzed the prospects for improving methods for predicting the characteristics of the active layer in the ocean.

Taking into account the importance of the problem of contamination for Armenia, the agenda of the seminar-school included examination of the problem of propagation of an impurity in the atmosphere over Armenia. M. Ye. Berlyand presented the principles of the theory of atmospheric diffusion with its applications to computations and forecasts of air contamination. The speaker cited a series of results of both an experimental and a theoretical nature, and in particular, applicable to the conditions prevailing in Armenia.

A report by G. A. Melkonyan examined problems relating to numerical modeling of the process of propagation of substances contaminating the atmosphere over Armenia.

In addition to those mentioned above, several interesting reports were presented on the general problems relating to atmospheric dynamics (L. V. Rukhovets, Ye. Ye. Kolenkovich, and others).

The work of the seminar-school demonstrated that such a method for the broad discussion and popularizing of ideas on major and important problems in the science of forecasting the state of the environment is useful and promising. Such seminar-schools favor not only the attraction of capable youth to the problem of long-range weather forecasting, but also solution of the problems developing in the considered subject matter field.

NOTES FROM ABROAD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 126-127

[Article by B. I. Silkin]

[Text] Specialists in the field of atmospheric electricity B. Edgar (Aerospace Corporation, Los Angeles, California) and B. N. Terman (Center for Applied Aviation Technology, United States) presented a report at a conference of the American Geophysical Union, held in San Francisco in December 1977.

The report describes the results of a first investigation of lightning discharges carried out using equipment carried aboard the "DMSP" meteorological satellite. There was registry of lightning discharges associated with meteorological activity along fronts, occurring over all the states of the southeastern United States, over the Gulf of Mexico and the Caribbean Sea.

The analysis revealed that at sunrise lightning is observed most frequently over the ocean, whereas at sunset it is observed most frequently over the land.

A map compiled on a preliminary basis gives reason for assuming that on a global scale during the sunrise period thunderstorms are distributed rather uniformly over the earth, whereas during the sunset period there is a tendency for them to be concentrated over the continents. The thunderstorms occurring in the second half of the day are associated with upward-directed thermal convection of air masses receiving heat from the sun-heated underlying surface of the land.

The strength typical in the observed lightning is about 10 billion watts. The duration is approximately 1 msec. However, several times there were discharges with a strength of about 100 billion watts and a duration up to 2 msec. Lightning with a strength of 10 trillion watts, earlier reported on the basis of observations from aboard the VELA satellite, for the time being has not been registered in these experiments.

In July 1977 scientific specialists at NOAA in the United States H. B. Stuart and J. Proni established that in the Gulf of Mexico there is an annular warm current. This current is a closed flow of slowly moving water masses with a diameter of about 225 miles. Their temperature is approximately 1°C higher than the temperature of the surrounding waters.

Continuing the observations, H. B. Stuart and J. Proni discovered a relationship between this current and hurricane Anita, developing on 28 August 1977. As the hurricane moved in the direction of the center of this annular current the intensity of the hurricane increased. The beginning of the sharp increase observed here coincided with the moment when the hurricane entered the "ring" of the current on its western side.

Detailed meteorological and oceanological observations were made both a month before the hurricane and during its course and after it; this yielded a great mass of data characterizing interaction between the ocean and the atmosphere. An important fact was that the sea surface after passage of the hurricane was cooled by 4°C.

The opinion is expressed that hurricanes can draw part of their energy from warm annular currents and as a result of this process can substantially increase their intensity.

According to the opinion prevailing up to now, in the event of a partial melting of the glaciers in Western Antarctica there should be an increase in sea level and this rise should be identical in all regions of the world ocean.

Now J. A. Clark (University of Colorado, Boulder, Colorado) and Z. S. Lingl (University of Maine, Orono, Maine) express a new opinion. They indicate a need for taking into account the inevitable changes in structure of the ocean floor under the influence of the changing loads arising with transformation of part of the ice into sea water and its redistribution in different basins.

In addition, in their opinion, the degree of rising of sea level should also change with time, since the rapid initial elastic deformation of the ocean bed must be followed by processes of inflow of viscous materials from the deep layers of the earth, which would gradually compensate the effect of the new distribution of the weight load on the crust.

In particular, according to the calculations of these specialists, as a result of melting of the West Antarctica ice dome over the period of the next 1,100 years, near the shores of the Ross ice shelf and Cape Horn the sea level should fall off as a result of a rise of the ocean floor in the adjacent regions. Near the Hawaiian Islands the rise in sea level must be 25% greater than the average for the entire world ocean. Similarly, in all regions located distant from the glacier cover, for example, along the shores of New York State or in the North Sea, the rise in sea level will initially be 10-15% greater than the average for the earth, and then, after approximately a thousand years, will gradually become equal to it.

A portable lidar, used for observing tornadoes and waterspouts, based on use of the Doppler effect, has been constructed at the scientific research laboratories of NOAA in the United States.

The new instrument, whose length is 120 cm and whose height is 50 cm, is easily carried aboard aircraft-laboratories of any type at the disposal of American meteorologists. The instrument consists of an ordinary 30-cm telescope and a laser operating on carbon dioxide. It makes it possible, with a great accuracy, to determine the velocity and direction of movement of the air captured by the waterspout.

During the first flights in the summer of 1977 this apparatus already made it possible to study the previously mysterious "double-walled" waterspouts. It has been established that their diameter can attain 30 m. The structure of such waterspouts differs, it was found, in that they consist of two different eddies which rotate at different velocities, but in one and the same direction.

The velocity of such rotation can attain 90 km/hour. In section a "double-walled" waterspout has the configuration of two concentrically arranged bells. An investigation of such winds, sometimes dangerous for both surface structures and for aerial transport, is continuing on a major scale with ever-greater use of the latest instrumentation.

OBITUARY OF SERGEY VASIL'YEVICH SOLONIN (1923-1978)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 11, Nov 1978 pp 127-128

[Article by a group of comrades]

[Text] Professor Sergey Vasil'yevich Solonin, Doctor of Physical and Mathematical Sciences, died after a short but severe illness on 24 June 1978. He was an outstanding scientist and a leading specialist in the field of aviation meteorology, head of the Department of Space and Aviation Research Methods in Hydrometeorology of the Leningrad Hydrometeorological Institute. S. V. Solonin was a member of the CPSU.

S. V. Solonin was born on 6 October 1923 at Sukhinichi in Kaluzhskaya Oblast.

In 1952, upon graduating with distinction from the meteorology department of the hydrometeorological faculty, S. V. Solonin was sent to serve as an instructor at the Leningrad Hydrometeorological Institute. All his subsequent creative and pedagogic activity is associated with this institute. There he moved along the long route from instructor to department head. There the creative capabilities and talents of Sergey Vasil'yevich were developed to the fullest degree. During 1952-1957 he carried out a whole series of investigations important for aviation meteorology and aerial navigation. A brilliant mathematician, Sergey Vasil'yevich during this period solved a series of problems related to the movement of an aircraft in the field of a variable wind, the problem of the trajectory of the minimum flight time for an aircraft (Tsermelo problem), for the first time applied the Fermat principle, well known from physics, for calculating the trajectory for the minimum flight time of an aircraft. In these studies fundamental scientific findings were combined with mathematical refinement. S. V. Solonin was one of the founders of a new scientific direction -- navigational meteorology.

In 1959 S. V. Solonin was awarded the degree of Candidate of Physical and Mathematical Sciences.

Sergey Vasil'yevich was the initiator and propagandist of a new approach in the scheduling of aircraft traffic for civil aviation which takes into account the climatic characteristics of the equivalent wind.

On the basis of the results of these investigations, jointly with G. G. Narovlyanskiy, in 1962 he published the monograph EKVIVALENTNYY VETER I METODY YEGO RASCHETA (The Equivalent Wind and Methods for its Computation).

In 1967, at the USSR Hydrometeorological Center, S. V. Solonin defended his doctoral dissertation, and in 1971 he was awarded the title of professor.

The period 1965-1978 in the life of Sergey Vasil'yevich was characterized by great creative attainments.

S. V. Solonin published a total of more than 130 scientific studies, among which, as a co-author, he wrote the textbook AVIATSIONNAYA METEOROLOGIYA (Aviation Meteorology), which has gone through two editions.

During recent years S. V. Solonin has been actively engaged in problems relating to space meteorology.

Sergey Vasil'yevich was no office scientist. He put all his scientific ideas to practical application, over a period of years being the scientific director of many investigations carried out for the enterprises of the Civil Aviation Ministry and for institutes of other departments.

The "Automated System for Meteorological Support of Flights" (Avtomatizirovannaya Sistema Meteorologicheskogo Obespecheniya Poletov -- ASMOP), in combination with the "Automated System for Navigation Computations" (Avtomatizirovannaya Systema Shturmanskikh Raschetov -- ASShR), was developed under the direction of S. V. Solonin.

S. V. Solonin successfully combined his scientific-teaching activity with public work. He was repeatedly elected a member of the Party bureau of the institute. He headed different Party-public commissions.

S. V. Solonin was a major scientific organizer. He inspired the idea of centralization and coordination of all the scientific research work in the field of aviation meteorology. In 1965 he created the Scientific Research Institute of Aviation Meteorology at the Leningrad Hydrometeorology Institute and in 1972 the Department of Space and Aviation Research Methods in Hydrometeorology and remained its head to the end of his days.

S. V. Solonin generously shared his knowledge and experience with his student. More than 20 Candidate's dissertations were prepared and defended under his direction.

Sergey Vasil'yevich had exceptional purposefulness, persistence, unlimited devotion to science, enormous love of work, optimism, complete dedication to work, and at the same time modesty and good will. He left this life at the height of his creative forces, full of scientific innovations, remaining on the job to the last minute.

The bright memory of a great scientist, an enthusiast and optimist, teacher, colleague and comrade will forever remain in our hearts.

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